An Investigation of Snow Lake and Herblet Lake in Relation to an Inoperational Gold Mine Complex

Water Standards and Studies, Report #84-2

Manitoba
Environment
and Workplace
Safety and Health

AN INVESTIGATION OF SNOW LAKE AND HERBLET LAKE IN RELATION TO AN INOPERATIONAL GOLD MINE COMPLEX

A. E. Beck
Water Standards and Studies Section,
Environmental Management Services Branch,
Environmental Management Division.

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Beck, A. E. 1984

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ABSTRACT

An ore concentrate stockpile and a tailings disposal site are located near the inoperational gold mine complex at Snow Lake, Manitoba. Leachate from the stockpile has resulted in elevated arsenic levels in the water column and sediments of Snow Lake. Tailings leachate has resulted in elevated arsenic levels in the water column, sediments and fish of the south-western part of Herblet Lake. Elevated copper levels in sediments of this area were also attributed to tailings leachate.

SUMMARY

The proximity of an arsenical gold ore concentrate stockpile and a tailings disposal site to the Town of Snow Lake has caused concerns regarding the potability of the Town's water supply (Snow Lake) and the water quality of nearby Herblet Lake. Water Standards and Studies Section addressed these concerns by carrying out an investigation in July, 1981. Metal levels in fish and sediments and a number of physicochemical parameters in the water columns of Snow and Herblet Lakes were examined. Drainage patterns and metal concentrations at both the stockpile and tailings site were also considered.

The pattern of drainage from the ore concentrate stockpile was towards Snow Lake via Canada Creek. Stockpile leachate had resulted in arsenic levels elevated beyond background in proximal areas of both the water column and sediments of Snow Lake. However, waters remained potable as mean arsenic concentrations (0.004 mg/L) were well below both the Manitoba surface water quality objective (0.01 mg/L) and the federally recommended maximum acceptable concentration (0.05 mg/L). Other parameters examined and fish were not detectably affected.

The pattern of drainage from the tailings disposal site was through a small bog towards Herblet Lake. Tailings leachate had resulted in arsenic levels elevated beyond background in the water column, sediments and fish of the southwestern portion of Herblet Lake. Copper concentrations in sediments were also found to be above background. Sewage discharges through the tailings area have moderated the potential for acid production and a minor alkalization has occurred in Herblet Lake. Other parameters examined showed no detectable impacts upon the water column, sediments and fish of Herblet Lake.

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INTRODUCTION

A gold mine and mill complex were operated at Snow Lake (54°53' 100°01') from 1949 to 1958. A total of 4,933,253 tonnes of ore were milled, producing 19,178.57 kilograms of gold and 1,562.55 kilograms of silver. Due to elevated arsenic levels which interfered with the amalgamation process, a further 226,800 tonnes of ore concentrate were stockpiled. Both the processed tailings and stockpiled concentrate had been subject to floatation - cyanidization treatment.

Concerns were expressed regarding possible arsenic contamination of the water supply for the Town of Snow Lake. Additional concerns were expressed regarding possible degradation of Herblet Lake water quality due to metal leachate and/or acid drainage from the tailings disposal site. Accordingly, Water Standards and Studies Section conducted a study of the area during July 6-11, 1981. The objectives of the study were:

1) To determine whether arsenic and other heavy metals were being leached and low pH waters were draining from the concentrate stockpile to Snow Lake;
2) To determine whether heavy metals were being leached and low pH waters were draining from the tailings disposal site to Herblet Lake;
3) To determine the extent of metal uptake by the fish in Snow and Herblet Lakes.

AREA DESCRIPTION

The study area lies approximately 550 kilometres north-northwest of Winnipeg (Figure 1). Physiographically, the area falls within the Precambrian Drift Plain subregion as the predominantly granitic bedrock is overlain by varying thicknesses of glacial drift (Weir, 1960). The topography is rolling to rugged with frequent rock outcrops. Peat deposits, podzols and grey wooded are the dominant soil types encountered (Ibid). Mixed stands of aspen, jackpine and spruce dominate the vegetational communities.

Snow Lake

Snow Lake (54°52', 100°03') is a relatively small lake with a surface area of some 5.26 square kilometres (Figure 1). Approximately 10 kilometres long, it is a narrow, reverse "S" shaped lake oriented in a northwest-southeast direction. The maximum depth appears to be 17.4 metres (Stewart-Hay, 1963). Detailed morphometric data is currently unavailable.

Snow Lake receives drainage from a total of 325 square kilometres (Fedoruk, 1970). The bulk of the inflow enters the extreme western end of the lake via the McLeod River. Canada Creek, in which drainage basin the concentrate stockpile is located, provides only minor inflows. The outflow, Snow Creek, is located at the eastern end of the lake and flows to Wekusko Lake on the Grass River system.

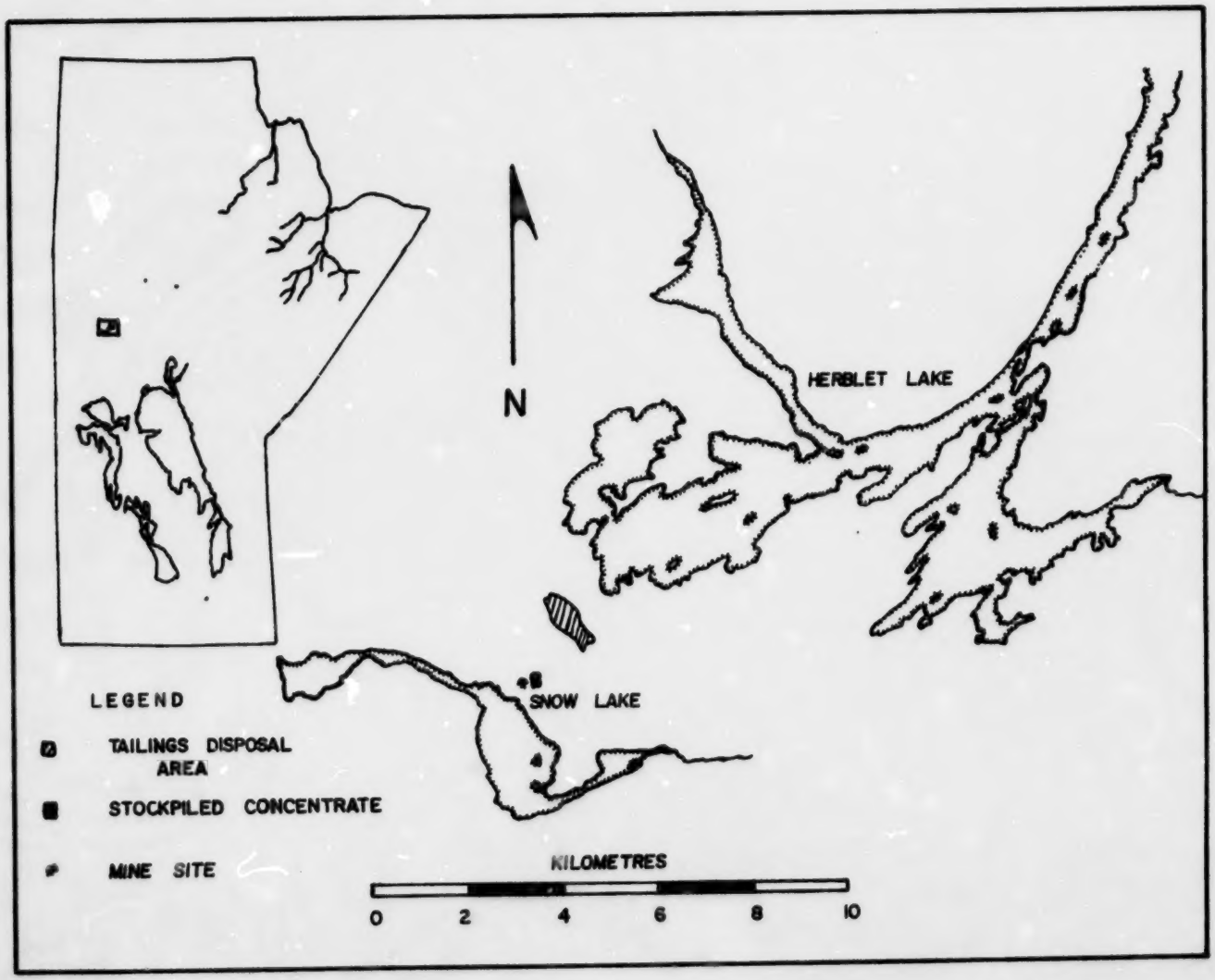

Figure 1, Overview of the Study Area.

Rock rubble materials dominate the lake edge. The southernmost shoreline of the lake consists primarily of meta-volcanic rocks (Davies et al, 1962) which rise steeply to heights in excess of 30 metres above lake level. The northernmost shoreline, composed mainly of gneisses to the west and meta-volcanic rocks to the east (Ibid), rises more gradually to an average of approximately 12 metres above lake level.

Snow Lake serves as the source of domestic water supply for the adjacent community of Snow Lake and as a base for several float-equipped aircraft. Town residents utilize a local beach site for swimming and pursue some minor angling and boating activities on the lake. Commercial fishing is not conducted on Snow Lake.

Herblet Lake

Herblet Lake ($54^{o}56'$, $99^{o}54'$) is a medium sized lake with a surface area of some 30.1 square kilometres (Figure 1). The lake is somewhat "X" shaped with orientation towards each of the secondary compass points. The maximum overwater length is approximately 17.0 kilometres. Detailed morphometric data is currently unavailable.

Herblet Lake receives drainage from a total of 320 square kilometres (Fedoruk, 1970). Numerous minor streams, none of great hydrological significance, contribute runoff to the lake. However, the unnamed minor stream draining the tailings disposal site to Southwest Bay is of particular interest. The outflow is located on South-east Bay and flows to Wekusko Lake via Wekusko Brook.

Materials of the Herblet Lake shoreline are diverse and range from organic (peat bog) to cobble, boulders and consolidated bedrock outcrops. Sand beaches are not a significant form. Back shoreline areas are also variable in relation to slope and altitude above lake level. The geology is complex as gneisses dominate the Southwest Bay shoreline, metavolcanic rock the shorelines of Angus and Southeast Bays and granitic rocks, gneisses and metavolcanic rocks the shoreline of Northeast Bay (Davies et al, 1962).

Recreationally, Herblet Lake is of minor importance in the area. Numerous reefs and an apparently insignificant walleye population deter local interest. However, the lake has supported a 9080 kilogram whitefish and pike commercial fishery for a number of years. Some trapping is also conducted around the lake.

SUMMARY OF MINE AND MILL OPERATIONS*

Claims covering the orebody were recorded in 1925. These were transferred to Nor-Acme Gold Mines Limited in 1941 and exploratory drilling began. Ore reserves were estimated to be 4,409,734 tonnes averaging 4.67 g/tonne gold. Following property subletting to the Howe Sound Exploration Company, headframe construction commenced in 1946. Electrical power was brought to the site by the Churchill River Power Company Limited transmission line from the Sherridon substation. The shaft and a floatation-cyanidization mill were completed and ready for operation by mid 1949.

The orebody was located immediately north of the present Snow Lake townsite. It consisted of silicified brecciated rock mineralized with arsenopyrite, pyrrhotite and pyrite with gold as minute lenticular masses and veinlets in the arsenopyrite. Small amounts of chalcopyrite, cubanite, sphalerite, galena, ilomenite and scheelite were also reported from the ore zones.

The mine and mill operated on the strength of this deposit from June, 1949 to September, 1958. During the life of the mine, a total of 4,933,253 tonnes of ore were milled, producing 19,178.57 kilograms of gold and 1,562.55 kilograms of silver. Additionally, 226,800 tones of arsenical concentrate averaging 7.9 g/tonne gold were stockpiled. Nor-Acme Gold Mines Limited regained control of the deposit in 1959 and currently holds the site under an explored area lease.

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*Summarized from Mineral Development Sector, 1973

STUDY METHODS AND MATERIALS

Study Design

Three sampling blocks per lake were selected for study purposes. Regarding Snow Lake (Figure 2), the influent area (Block "A") was selected as the control and the effluent area (Block "C") was considered representative of a cumulatively impacted area downstream of the potential contaminant drainage path. The area immediately adjacent to the mouth of Canada Creek (Block "B") was considered likely to be most adversely affected. A similar rationale was applied to selection of Herblet Lake (Figure 3) sampling areas. Angus Bay was designated the control (Block "D"), and the outlet on Southeast Bay was considered the downstream area (Block "F"). The west tip of Southwest Bay was thought likely to be most adversely affected (Block "E").

A total of ten sampling stations per block were randomly identified. This was accomplished by superimposing a numbered grid upon diagrams of each block and utilizing random number tables (Rand Corp., 1955) to determine grid reference points.

Field Procedures

The collection of perishable samples was arranged to correspond with the regularly scheduled bus service from Snow Lake to Winnipeg. Technical Services Laboratory receipt of these samples was thus assured within twenty-four hours of collection.

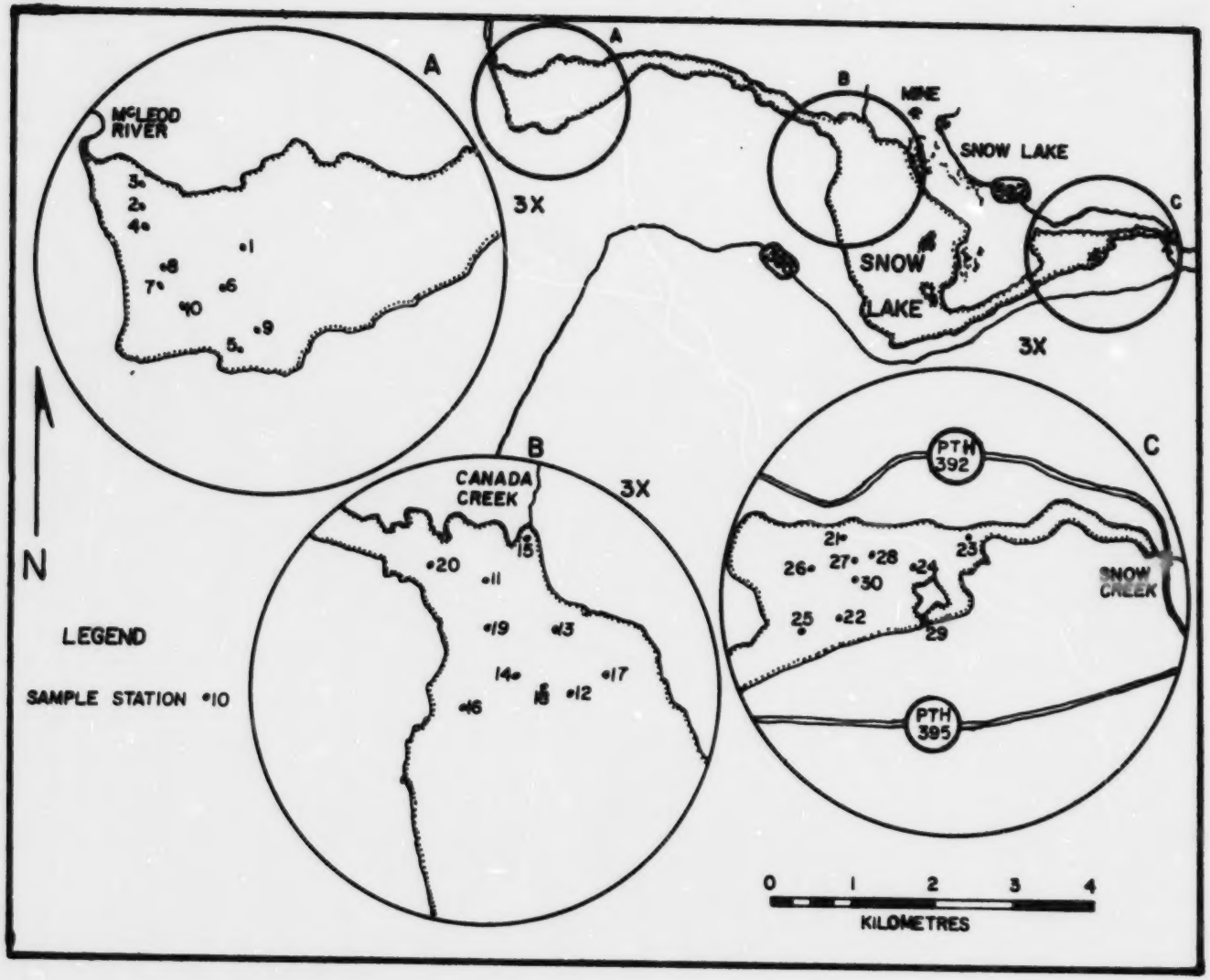

Figure 2. Snow Lake Sampling Sites.

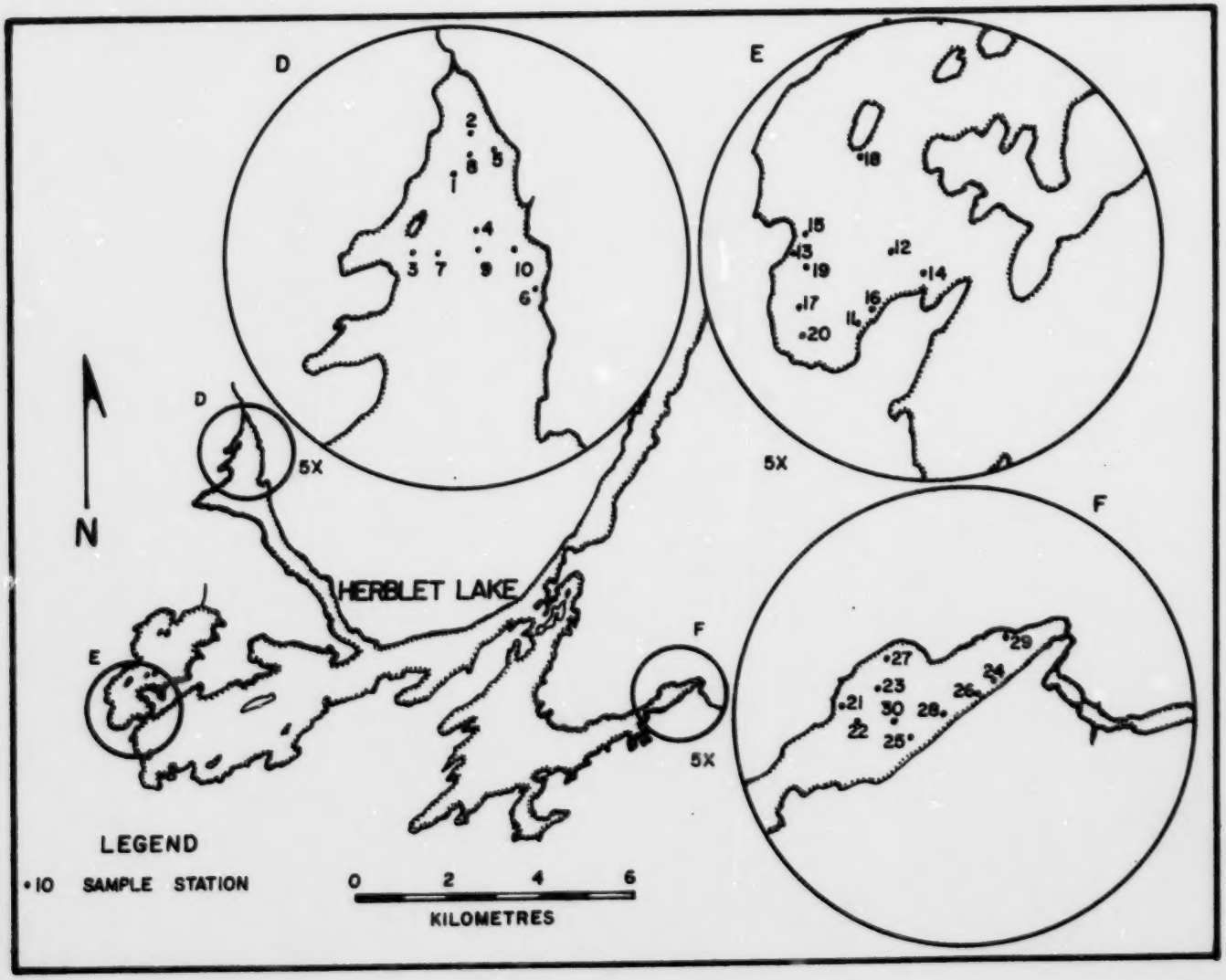

Figure 3. Herblet Lake Sampling Sites

A four litre acrylic Kemmerer sampler was used to collect water at random depths from each of the stations. Random depths were determined by considering random numbers (Ibid) as a percentage of the total depth of each station. Single samples were also collected from drainage at the concentrate stockpile and at the tailings disposal site. Volumes collected were sufficient for laboratory analysis of the requested eleven physicochemical parameters, nine metals and three nutrients as well as free and total cyanides.* Water temperatures were measured and recorded on site.

Original intentions to sample sediments with an impact coring device proved impractical due to insufficient compaction of sedimented materials. Instead, sediments were collected by a 22.9 centimetre square Ekman dredge. Upon hoisting the Ekman grab to the lake surface, the top of the dredge was carefully opened so as to not disturb the delicate water-sediment interface. A five centimetre diameter clear acrylic tube was then inserted through the dredge contents. Excess water and sediments more than five centimetres below the interface were carefully drained from the pipe. The remainder of the sample was placed in a labelled "whirl-pak" plastic bag. Duplicate samples were collected from every fifth station in each sampling block. Sampling of sediments was conducted in conjunction

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* Parameters listed in Table 1.

with that of water in order to ensure shipment and receipt by analytical staff within twenty-four hours of collection. Accompanying the sediment samples were analytical requests for nine metals and both free and total cyanides (duplicates only).*

Fish were collected by deploying overnight gangs of 76.2, 85.3 and 108 mm. mesh gill nets at suitable locations within sampling blocks "B" and "E". The total catch per block was identified to species and tallied. A maximum of twenty individuals per species per lake were collected and sampled. The samples represented the size range of walleye (Snow Lake only), northern pike, common sucker, cisco (Herblet Lake only) and lake whitefish (Snow Lake only) collected. Each individual was assigned an identifying number, weighed to the nearest 10 grams, measured to the nearest 0.1 centimetre and sexed. Evidences of age, consisting of either otoliths, cleithra, dorsal spines and/or pelvic fin rays (species dependant), were removed. Specimens were then filleted and the lateral muscle tissue inserted in labelled "whirl-pak" plastic bags. Muscle tissue samples were shipped to analytical staff within fourty-eight hours of collection and were accompanied by analytical requests for arsenic, cadmium, copper, lead, mercury, nickel and zinc.

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* Parameters listed in Table 4.

The tailings disposal site and concentrate stockpile (Figure 4) were searched for evidence of surface runoff to Herblet Lake and Snow Lake, respectively. The locations of effluent streams were documented. Additionally, four samples were taken from various locations on each of the tailings and concentrate piles. All samples were shipped to analytical staff within twenty-four hours of collection. Analyses requested were identical to that of regular sediments.

Analytical Procedures

Upon receipt by the Technical Services Laboratory, all water, tailings and duplicate sediment samples were refrigerated. The remaining sediments and all biological samples were placed in freezers. All samples were analyzed prior to shelf life expiration according to methods described by Sorba et al (1980).

Fish evidences of age were submitted for age determination to the Department of Natural Resources, Biological Services Branch.

Upon completion of analyses, all data were tabulated and summarized. Analysis of variance was performed on water and sediment chemical parameters. Regressions of block "B" and "E" metal concentrations (µg/g) on estimated direct water distance (km) from each adjacent influent stream mouth were also calculated and tested for significance (t_{α}=0.05).

Mean metal concentrations in the muscle tissue of fish were compared between Snow and Herblet Lakes and to similar data from Wekusko Lake (Brown et al, 1980) and Gods Lake (Beck, 1982).

RESULTS AND DISCUSSION

WATER PHYSICOCHEMISTRY

Water physicochemical data for Snow and Herblet Lakes are detailed in Appendices 1 and 2, respectively and summarized in Tables 1 and 2, respectively. The results of analysis of variance are presented in Table 3.

a) Snow Lake

The general water physicochemical results for Snow Lake showed influence by the weather conditions at various sampling times as well as by the physical features of each sampling block. Some of the metals were influenced by loadings from Canada Creek.

Block mean temperatures (Table 1) tended to increase from "A" through "C" presumably as a reflection of respective sampling and total depths (Appendix 1). Above the 6.0m level, water temperatures were uniform at 19.0°C. A thermocline was evident at the 6.0 to 8.0m level as temperatures dropped from 15.0°C to 13.0°C, respectively. The lowest temperature recorded, 10.0°C, was observed at the 11.0m level. It is probable that the thermal stratification of Snow Lake was relatively stable due to the sheltered nature and small size of the lake.

Block mean conductivities (Table 1) were the first indication that inflows from Canada Creek may be impacting upon Snow Lake. Though block "B" and "C" means were only about 10% greater than that of "A", the difference was significant at F0.95 (Table 3). Most

TABLE 1. SUMMARY OF SNOW LAKE PHYSIOCHEMICAL DATA

SAMPLING BLOCK		"A"					"B"					"C"			
PARAMETER / STATISTIC*		$\bar{X}$	δ	HI	LO		$\bar{X}$	δ	HI	LO		$\bar{X}$	δ	HI	LO
Field Temperature	°C	17.10	3.28	19.0	10.0		18.4	1.897	19.0	13.0		19.0	0.0	19.0	19.0
Conductivity	µS/cm	106.60	2.37	110.	105.		116.4	6.077	132.	111.		114.4	2.17	117.	112.
Residue Nonfilterable	mg/L	<5.0	0.0	<5.0	<5.0		5.2	0.633	7.0	<5.0		12.5	5.85	26.0	7.0
pH	(logarithmic mean)	7.29	—	7.55	6.75		7.68	—	7.90	7.00		7.88		8.00	7.80
Alkalinity Total ($CaCO_3$)	mg/L	63.88	47.48	199.0	48.2		52.85	2.78	60.5	51.5		51.67	0.490	52.5	51.2
Alkalinity (HCO_3)	mg/L	77.98	57.99	243.0	58.9		64.42	3.41	73.8	62.8		63.01	0.567	64.0	62.5
Alkalinity (CO_3)	mg/L	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Alkalinity (OH)	mg/L	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Dissolved Oxygen	mg/L	5.79	3.12	8.0	0.3		7.29	1.78	8.6	2.8		8.22	0.452	8.9	7.2
T.O.C.	mg/L	18.05	0.643	19.0	17.0		16.85	0.78	18.5	15.5		18.2	0.789	19.5	17.0
T.I.C.	mg/L	10.3	1.252	12.0	8.0		9.15	1.63	12.0	7.0		7.85	1.081	9.5	5.5
Turbidity	NTU	—	—	—	—		—	—	—	—		—	—	—	—
Kjeldhal Total N	mg/L	0.54	0.07	0.7	0.5		0.54	0.052	0.6	0.5		0.560	0.052	0.6	0.5
NO_3-NO_2-N (Dissolved)	mg/L	0.011	0.003	0.02	< 0.01		0.018	0.022	0.08	<0.01		<0.01	0.0	<0.01	<0.01
P Total	mg/L	0.048	0.042	0.16	0.03		0.038	0.0079	0.05	0.03		0.044	0.011	0.07	0.03
Cyanide Total	mg/L	<0.02	0.0	<0.02	<0.02		<0.02	0.0	<0.02	<0.02		<0.02	0.0	<0.02	<0.02
Cyanide Free	mg/L	<0.02	0.0	<0.02	<0.02		<0.02	0.0	<0.02	<0.02		<0.02	0.0	<0.02	<0.02
As (Total)	mg/L	0.0028	0.0008	0.004	0.002		0.0054	0.0041	0.017	0.003		0.0045	0.0005	0.005	0.004
Cd (Ext)	mg/L	<0.005	0.0	< 0.005	<0.005		<0.005	0.0	<0.005	<0.005		<0.005	0.0	<0.005	<0.005
Cu (Ext)	mg/L	0.0268	0.0254	0.034	<0.005		0.0135	0.0113	0.037	<0.005		0.0175	0.0135	0.040	<0.005
Pb (Ext)	mg/L	<0.005	0.0	<0.005	<0.005		<0.005	0.0	<0.005	<0.005		0.0055	0.0016	0.010	<0.005
Ni Ext	mg/L	0.0058	0.0022	0.012	<0.005		0.0125	0.0149	0.045	<0.005		0.0106	0.0101	0.030	<0.005
Zn (Ext) (Dis)	mg/L	0.0210	0.0032	0.03	<0.02		0.02	0.0	0.02	<0.02		0.0270	0.0149	0.06	<0.02
Ca (Ext)	mg/L	12.0	1.41	13.0	10.0		13.2	0.633	15.0	13.0		16.3	2.26	18.0	13.0
Mg (Ext)	mg/L	5.0	0.0	5.0	5.0		5.0	0.0	5.0	5.0		5.0	0.0	5.0	5.0
Hg Total	µg/L	—	—	<0.02	<0.02		—	—	<0.02	<0.02		—	—	—	—

*NOTE: $\bar{X}$ = mean; δ = standard deviation; Hi = greatest value; LO = smallest value.

TABLE 2. SUMMARY OF HERBERT LAKE PHYSICOCHEMICAL DATA

SAMPLING BLOCK	"D"				"E"				"F"			
PARAMETER / STATISTIC*	$\bar{X}$	δ	HI	LO	$\bar{X}$	δ	HI	LO	$\bar{X}$	δ	HI	LO
Field Temperature °C	22.0	0.0	22.0	22.0	22.0	0.0	22.0	22.0	22.0	0.0	22.0	22.0
Conductivity µµS/cm	97.1	0.74	98.0	96.0	107.8	1.48	110.	105.	79.14	1.03	80.0	77.8
Residue Nonfilterable mg/L	5.2	0.63	7.0	<5.0	6.8	1.87	11.0	< 5.0	6.0	1.05	8.0	< 5.0
pH (logarithmic mean)	7.67	—	7.80	7.55	7.93		8.4	7.8	7.27		7.45	7.15
Alkalinity Total ($CaCO_3$) mg/L	40.025	0.343	40.5	39.25	41.10	0.39	41.5	40.5	32.785	0.598	33.65	32.0
Alkalinity (HCO_3) mg/L	48.89	0.348	49.0	47.9	50.10	0.74	49.0	51.0	39.97	0.79	41.2	39.0
Alkalinity (CO_3) mg/L	0.0	0.0	0.0	0.0	0.03	0.09	0.3	0.0	0.0	0.0	0.0	0.0
Alkalinity (OH) mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dissolved Oxygen mg/L	8.09	0.202	8.4	7.7	8.6	0.45	9.2	8.0	6.5	0.981	8.1	4.5
T.O.C. mg/L	15.45	0.832	17.0	14.5	19.65	0.47	20.5	19.0	15.5	0.745	16.5	14.5
T.I.C. mg/L	9.0	0.0	9.0	9.0	8.8	0.42	9.5	8.0	7.55	0.369	8.0	7.0
Turbidity NTU	2.35	0.530	3.0	1.5	3.55	0.37	4.0	3.0	2.55	0.550	3.5	2.0
Kjeldhal Total N mg/L	0.540	0.052	0.6	0.5	0.77	0.09	0.8	0.5	0.06	0.0	0.06	0.06
NO_3-NO_2-N (Dissolved) mg/L	0.013	0.009	0.04	0.01	0.01	0.0	0.01	< 0.01	0.01	0.0	0.01	0.01
P Total mg/L	0.037	0.016	0.07	0.02	0.078	0.013	0.10	0.05	0.053	0.013	0.08	0.04
Cyanide Total mg/L	< 0.02	0.0	<0.02	< 0.02	<0.02	0.0	<0.02	<0.02	<0.02	0.0	<0.02	<0.02
Cyanide Free mg/L	<0.02	0.0	<0.02	< 0.02	<0.02	0.0	<0.02	<0.02	<0.02	0.0	<0.02	<0.02
As (Total) mg/L	0.004	0.001	0.005	0.003	0.044	0.004	0.050	0.038	0.004	0.0012	0.006	0.003
Cd (Ext) mg/L	<0.005	0.0	<0.005	<0.005	<0.005	0.0	<0.005	<0.005	<0.005	0.0	<0.005	<0.005
Cu (Ext) mg/L	0.006	0.002	0.010	<0.005	0.007	0.003	0.015	0.005	0.026	0.038	0.110	<0.005
Pb (Ext) mg/L	0.005	0.0	0.005	<0.005	0.005	0.0	0.005	< 0.005	<0.005	0.0	<0.005	<0.005
Ni Ext mg/L	<0.005	0.0	<0.005	<0.005	0.006	0.002	0.010	< 0.005	<0.005	0.0	< 0.005	<0.005
Zn (Ext) (Dis) mg/L	0.02	0.0	0.02	< 0.02	0.02	0.0	0.02	<0.02	0.021	0.0032	0.03	<0.02
Ca (Ext) mg/L	12.4	1.265	13.0	10.0	13.0	0.0	13.0	13.0	9.2	1.033	10.0	8.0
Mg (Ext) mg/L	4.35	0.085	4.5	4.3	4.75	0.24	5.0	4.5	3.52	0.169	3.8	3.3
Hg Total µg/L	--	--	--	--	--	--	--	--	--	--	--	--

*NOTE: $\bar{X}$ = mean; δ = standard deviation; Hi = greatest value; LO = smallest value

TABLE 3. ANALYSIS OF VARIANCE OF SNOW AND HERBLET LAKES' PHYSICOCHEMICAL DATA

SAMPLING BLOCK		SNOW LAKE				HERBLET LAKE		
PARAMETER \ STATISTIC		F	d.f.	F.95		F	d.f.	F.95
Field Temperature	°C	1.97	2,27	3.35		0	2,27	3.35
Conductivity	µS/cm	17.03	2,27	3.35		1666.4	2,27	3.35
Residue Nonfilterable	mg/L	15.80	2,27	3.35		3.82	2,27	3.35
pH	(logarithmic mean)	- -	- -	- -		- -	- -	- -
Alkalinity Total ($CaCO_3$)	mg/L	0.89	2,27	3.35		886.48	2,27	3.35
Alkalinity (HCO_3)	mg/L	0.61	2,27	3.35		711.812	2,27	3.35
Alkalinity (CO_3)	mg/L	0.0	2,27	3.35		0.0	2,27	3.35
Alkalinity (OH)	mg/L	0.0	2,27	3.35		0.0	2,27	3.35
Dissolved Oxygen	mg/L	3.41	2,26	3.37		1.62	2,26	3.37
T.O.C.	mg/L	9.95	2,27	3.35		118.41	2,27	3.35
T.I.C.	mg/L	8.34	2,27	3.35		59.018	2,27	3.35
Turbidity	NTU	- -	- -	- -		17.236	2,27	3.35
Kjeldhal Total N	mg/L	0.39	2,27	3.35		36.60	2,27	3.35
NO_3-NO_2-N (Dissolved)	mg/L	1.15	2,27	3.35		1.00	2,27	3.35
P Total	mg/L	0.40	2,27	3.35		22.26	2,27	3.35
Cyanide Total	mg/L	0.0	2,27	3.35		0.0	2,27	3.35
Cyanide Free	mg/L	0.0	2,27	3.35		0.0	2,27	3.35
As (Total)	mg/L	2.93	2,27	3.35		861.889	2,27	3.35
Cd (Ext)	mg/L	0.0	2,27	3.35		0.0	2,27	3.35
Cu (Ext)	mg/L	1.46	2,27	3.35		2.66	2,27	3.35
Pb (Ext)	mg/L	1.00	2,27	3.35		0.0	2,27	3.35
Ni Ext	mg/L	1.086	2,27	3.35		1.00	2,27	3.35
Zn (Ext) (Dis)	mg/L	1.843	2,27	3.35		0.94	2,27	3.35
Ca (Ext)	mg/L	19.64	2,27	3.35		46.95	2,27	3.35
Mg (Ext)	mg/L	0.0	2,27	3.35		128.67	2,27	3.35
Hg Total	µg/L	- -	- -	- -		- -	- -	- -

importantly, the greatest conductivity recorded (132 µS/cm; Appendix 1(b)) was observed at station 15, the mouth of Canada Creek. Thus inflows from Canada Creek appear to have contributed ions in quantities sufficent to detectably elevate conductivity levels in Snow Lake.

Non filterable residues (Table 1) were noticeably affected by the action of strong winds stirring the shallow block "C" waters. Suspended sediment materials were observed in all block "C" samples and were believed to be the source of significant difference noted in Table 3. Evidence of significant loadings of non filterable residues by inflows from Canada Creek was not observed.

Block mean pH values (Table 1) tended to increase from "A" through "C"; again presumably as a reflection of respective sampling and total depths. Lower pH values were observed at all stations where samples were collected below the thermocline (Appendix 1). This depression of hypolimnetic pH is common in summer stratified lakes and results from a combination of euphotic zone photosynthesis and hypolimnetic decomposition of organic matter (Hutchinson, 1957). Because the pH at station 15 (7.55 units; Appendix 1(b)) was well above depressed hypolimnetic pH values (extreme 6.75 units; Appendix 1(a)), Canada Creek inflows cannot be considered a significant source of acid drainage to Snow Lake.

At first glance block means for both total and bicarbonate alkalinities (Table 1) appeared to contradict the pH data. Low mean pH should not be coupled with a high mean alkalinity. However, the higher block "A" mean alkalinities were positively influenced by apparent abnormally high values at station 7 (Appendix 1(a)). Excluding these anomalies by Dickson's outlier test yielded block "A" means of 48.9 mg/L $CaCO_3$ and 59.6 mg/L HCO_3; both of which were significantly lower (F = 13.44; F= 12.83, respectively) than the "B" and "C" means (unlike the indications of Table 3). At least some of the increased alkalinity (blocks "B" and "C") may be attributed to inflows from Canada Creek as station 15 total and bicarbonate alkalinities were each approximately 10 mg/L greater than the respective block "B" means. This lends support to the earlier conclusion that Canada Creek inflows were not a significant source of acid drainage to Snow Lake.

Dissolved oxygen levels, like pH, were heavily influenced by thermal stratification. All samples collected from above the thermocline were more than 75% saturated (Appendix 1 (a-c)). All samples taken from below the thermocline showed severe depletion, the extreme (0.3 mg/L; 2% saturation) occurring at a depth of 11.0m at Station 5 (Appendix 1(a). Hypolimnetic oxygen depletion is a normal occurrence in many summer stratified lakes and was not attributable to Canada Creek inflows.

Both block total organic carbon (TOC) and total inorganic carbon (TIC) evinced significant differences (Table 3). A reason for TOC differences was not evident. TIC differences may have been due to depth and stratification as well as varying rates of organic decomposition.

Mean nutrient levels (Total N, Dissolved N, Total P) were near uniform from block to block (Table 1) and therefore showed no statistically significant differences (Table 3). The nutrient concentrations were considered normal for small northern mesotrophic lakes such as Snow Lake (Vollenweider, 1968). Excessive nutrient inflows from Canada Creek were not evident.

Cyanide, used in the floatation process, is not stable in aquatic systems as it readily complexes with metallic and/or alkali ions (APHA et al, 1971). Evidence of cyanide contamination of Snow Lake was not observed. All samples registered less than detectable levels (i.e. <0.02 mg/L; Appendix 1).

Arsenic, a dominant metal in the mined orebody, is of particular importance to this study. Block mean values (Table 1) for "B" (0.0054 mg/L) and "C" (0.0045 mg/L) were slightly greater than in control block "A" (0.0028 mg/L). This difference was not significant at F0.95 (Table 3). However, station 15 arsenic concentrations (0.017 mg/L; Appendix 1(b)) were the highest encountered on Snow Lake and suggest that Canada Creek inflows were the source of the elevated levels noted in "B" and "C" waters. The regression [mg/L As = 1.174exp.-195.4(km)], which describes waterborne arsenic

concentrations (mg/L) as an exponential function of distance (km) from the mouth of Canada Creek, was significantly (t_{α} = 0.05) correlated (r^2 = 0.852) and thus tended to confirm that Snow Lake arsenic levels greater than background were derived from Canada Creek inflows. Regarding potability, mean arsenic levels in Snow Lake were well below both the Manitoba surface water quality objective of 0.01 mg/L (Clean Environment Commission, 1979) and the recommended maximum acceptable concentration of 0.05 mg/L (Federal-Provincial Working Group on Drinking Water, 1978). However, mean block "B" waters and the Canada Creek outflow arsenic concentrations (0.0054 and 0.017 mg/L resp.) exceeded the federally recommended objective concentration (≤0.005 mg/L).

Cadmium was unique among the metals analyzed in that levels above the 0.005 mg/L detection limit were not found in any of the water samples from Snow Lake (Table 1).

Block mean copper concentrations showed a progressive decline from blocks "A" through "C" (Table 1). Block mean differences, however, were not significant at F0.95 (Table 3). The possibility of a relationship between copper concentrations and proximity to the outlet of Canada Creek was also considered, but the exponential regression mg/L Cu= 0.383exp.4.786(km) was not significantly (t_{α}=0.05) correlated (r^2=0.004). Thus no evidence of significant copper loadings to Snow Lake waters by Canada Creek flows was detected.

The status of lead concentrations in Snow Lake waters closely approximated that of cadmium as lead was above the analytical detection limit in only one sample (0.010 mg/L, station 27, block "C"). Again, no evidence of significant loadings by Canada Creek waters was observed.

Minimal quantities of nickel were detected from samples of each block. Like arsenic, mean nickel concentrations were lowest at the control block ("A") and greatest at block "B" (Table 1). However, the difference between block means was not significant at F0.95 (Table 3). Also like arsenic, a significant (t_{α}=0.05) correlation (r^2=0.53) was observed for the exponential relationship (mg/L Ni = -0.430exp.-0.193(km)) between nickel concentrations and proximity to the mouth of Canada Creek. However, because sediment concentrations did not follow a similar pattern (discussed later), water column nickel concentrations were considered an anomaly.

Zinc frequently occurred at detectable levels in Snow Lake waters (Table 1). Block means showed no significant difference at F0.95 (Table 3). As the Block "B" mean was the lowest of the three values calculated, Canada Creek flows did not appear to have contributed zinc loadings to Snow Lake.

Water mercury levels were not adequately determined due to sampler contamination; a fact not discovered until completion of field work. Therefore results are presented only for surficial samples collected without the aid of specialized sampling equipment (Appendix 1). None of the five samples collected contained detectable concentrations of mercury.

Calcium and magnesium are of interest primarily because of their role in buffering acidity in water. Both were present in low concentrations and would provide a minimum of buffering capability (Table 1).

b) Herblet Lake

The general water physicochemical results for Herblet Lake appeared to be strongly influenced by the geology unique to each sampling block. Additionally, flows from the unnamed creek draining the tailings disposal area (hereinafter referred to as Tailings Creek) appeard to have affected waters of block "E".

All temperatures recorded from Herblet Lake sampling blocks were a uniform 22°C (Table 2). Moderate wind action upon the shallow waters of each of the blocks (maximum depth 3.2m, station 7) and the shallow sampling depths (maximum 2.9m, station 9) were thought responsible for temperature uniformity.

Conductivities within each sampling block were remarkably uniform as standard deviations were less than 2% of the mean (Table 2). Block mean conductivities, however, differed significantly at F0.95 (Table 3). Though the geological formations peculiar to the watersheds of each sampling block were most likely the source of the differences, it was probable that conductivities of block "E" waters were also somewhat elevated by flows from Tailings Creek. Flows from Tailings Creek were expected to demonstrate elevated conductivities due to both dissolution of tailings materials and the presence of effluents from the Town of Snow Lake's Imhoff tank sewage treatment

system. This could not be confirmed because of the floating bog character of the Tailings Creek mouth which prevented the collection of a clearly defined sample of flow from the tailings area.

Herblet Lake non filterable residues (Table 2) were also noticeably affected by wind action. Stations nearest windward shores (eg. stations 15 and 20 of block "E", stations 24 and 25 of block "F") demonstrated greater residue levels than did leeward and more central stations. As block "E" was more exposed to wind influences than either of blocks "D" and "F", the significantly greater non filterable residue levels of block "E" (Table 3) were attributable to wind action and not loadings from Tailings Creek.

Block mean pH values varied from 7.93 units at block "E" to 7.27 units at block "F" (Table 2). Analysis of variance was not performed because pH is not a normally distributed parameter (i.e.β^2 is related to μ). However because overlap in block value ranges was not observed and as both mean total and mean bicarbonate alkalinities were observed to differ significantly (Table 3), it was assumed that block mean pH differences were also of consequence. Although waters receiving drainage from a mine tailings area might be expected to demonstrate a depressed pH, block "E" waters were in fact somewhat alkalized in comparison to downstream and background conditions (blocks "F" and "D", respectively). A plausible explanation of this phenomenon (acidic input resulting in lake alkalization) has been proposed by Kilham, (1982). Kilham thoerized that biologically mediated processes yield alkalinity by the uptake of

nitrates and the reduction of sulfates, thereby neutralizing the hydrogen ions entering the system from acid precipitation. Lake alkalinity is increased by carbonate drainage from watersheds undergoing accelerated weathering of basic rock. Essential to the process are either abundant nutrients for the promotion of aquatic plant growth or the presence of large quantities of organic materials on the lake. Both conditions were met as nutrient rich sewage effluent was being discharged to the area and the mouth of Tailings Creek was of a boggy nature. It was therefore concluded that drainage from the tailings disposal area was causing moderate alkalization of block "E" waters. Observed pH and alkalinities tended to support this conclusion.

Unlike Snow Lake, dissolved oxygen levels in Herblet Lake were not influenced by stratification due to the shallow depth within each sampling block. Saturation levels ranged from 54% to 103%. Differences between block means were not observed (Table 3).

Total organic and total inorganic carbons showed significant differences between block means (Table 3), indicating the occurrence of greater primary productivity within block "E". Increased plant growth in this area appeared to be promoted by significantly greater phosphorus availability (Table 3). As mentioned earlier, the source of the nutrients appeared to be sewage effluent discharged to the tailings disposal area and thence via Tailings Creek to block "E".

Like Snow Lake, evidence of cyanide contamination was not observed in Herblet Lake as all samples registered less than the analytical detection limit (i.e. <0.02 mg/L; Appendix 2).

Arsenic showed a significant difference between block means (Table 3). Block "E" mean arsenic concentrations averaged one order or magnitude greater than either of blocks "D" or "F" (0.044, 0.004, and 0.004 mg/L; respectively; Table 2). It was apparent that the increased arsenic levels had originated with drainage from the tailings disposal area. However, attempts to correlate station concentrations of arsenic to distance from the mouth of Tailings Creek did not yield significant regressions. Evidently, arsenic was relatively evenly distributed throughout block "E" waters as the dimensions of the sampling block were not great enough to yield dilute samples at the periphery of the block. Complete mixing of block "E" water would have resulted from minimal flows from Tailings Creek and wind action upon the shllow waters prior to the time of survey.

Cadmium levels above the 0.05 mg/L detection limit were not observed in Herblet Lake water samples (Appendix 2).

Background block "D" and block "E" mean copper concentrations were similar (0.006 and 0.007 mg/L, respectively, Table 2). The outlet area was somewhat greater at 0.026 mg/L (Table 2) but the differences were not statistically significant (Table 3).

Block mean concentrations for lead, nickel and zinc fluctuated narrowly about the detection limits (0.005, 0.005 and 0.02 mg/L, respectively, Table 2) and showed no statistically significant differences (Table 3).

Mercury concentrations in the water column were not considered due to the problem of sampler contamination discussed earlier.

Like Snow Lake, neither calcium nor magnesium were present in concentrations adequate to provide much buffering capability (Table 2).

SEDIMENTS

Metal and cyanide levels in sediments from Snow and Herblet Lakes are detailed in Appendix 3 and 4, respectively. These data have been summarized and are presented with the respective analyses of variance in Tables 4 and 6. The regressions of metal concentrations in blocks "B" and "E" sediments on distance from the mouths of Canada Creek and Tailings Creek are described in Tables 5 and 7, respectively.

a) Snow Lake

Block mean concentrations of mercury, lead, zinc and iron in Snow Lake sediments were not significantly different at F0.95 (Table 4). Additionally, correlations for the regressions of the concentrations of these metals on distance from the mouth of Canada Creek were not significant (Table 5). Thus there were no indications that Canada Creek flows have carried significant quantities of these metals to Snow Lake sediments. This conclusion compared favourably with the water column data.

TABLE 4. SUMMARY AND ANALYSIS OF VARIANCE OF SNOW LAKE SEDIMENT DATA

SAMPLING BLOCK	PARAMETER / STATISTIC*	Hg (wet) (µg/g)	Hg (µg/g)	As (µg/g)	Cd (µg/g)	Cu (µg/g)	Pb (µg/g)	Ni (µg/g)	Zn (µg/g)	Fe (%)	Mn (µg/g)	CN (µg/g)
A	$\bar{x}$	0.022	0.078	21.6	1.8	86.0	25.0	30.0	107.0	1.85	441.8	< 2.0
	δ	0.004	0.053	9.9	0.63	17.76	15.46	17.3	46.86	1.48	204.8	0.0
	Hi	0.03	0.16	37.0	3.0	100.0	40.0	42.0	140.0	3.36	643.0	< 2.0
	Lo	< 0.02	0.02	7.4	< 1.0	50.0	< 5.0	5.0	30.0	0.33	131.0	< 2.0
B	$\bar{x}$	0.023	0.068	112.9	1.4	58.1	35.0	34.2	109.5	2.28	675.8	< 2.0
	δ	0.005	0.044	115.8	0.52	32.39	15.28	17.97	55.6	1.355	534.0	0.0
	Hi	0.03	0.12	470.0	2.0	100.0	55.0	52.0	190.0	3.89	1855.0	< 2.0
	Lo	< 0.02	< 0.02	8.0	< 1.0	< 1.0	15.0	5.0	20.0	0.41	123.0	< 2.0
C	$\bar{x}$	0.02	0.11	34.4	1.0	51.0	22.5	44.9	90.5	1.65	228.6	< 2.0
	δ	0.0	0.046	16.2	0.0	23.78	5.4	13.54	23.62	0.41	65.48	0.0
	Hi	0.02	0.17	73.0	1.0	110.0	30.0	63.0	110.0	2.01	292.0	< 2.0
	Lo	< 0.02	0.03	10.0	< 1.0	20.0	10.0	18.0	35.0	0.77	75.0	< 2.0
ALL	F	1.70	2.11	2.97	7.20	5.32	2.62	2.20	0.55	0.72	4.53	- -
	d.f.	2,27	2,27	2,27	2,27	2,27	2,27	2,27	2,27	2,27	2,27	- -
	F.95	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35

*NOTE: $\bar{X}$ = mean
δ = standard deviation
Hi = greatest value
Lo = smallest value

TABLE 5. REGRESSIONS OF BLOCK "B" SEDIMENT METAL CONCENTRATIONS ON DISTANCE* FROM THE MOUTH OF CANADA CREEK

Where: µg/g=aexp.b(km)	Hg(dry) (µg/g)	As (µg/g)	Cd (µg/g)	Cu (µg/g)	Pb (µg/g)	Ni (µg/g)	Zn (µg/g)	Fe (%)	Mn (µg/g)
a	0.508	0.640	0.218	0.341	0.179	0.224	0.240	0.312	0.314
b	-3.185	-0.004	0.449	0.003	0.024	0.018	0.005	0.001	0.0004
r^2	0.026	0.504	0.071	0.014	0.172	0.131	0.096	0.034	0.057
$H_0:\beta = 0$ ($t\alpha = 0.05$)	ACCEPT	REJECT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT

* Block "B" Station Distances (km) from the mouth of Canada Creek:

STATION	DISTANCE (km)	STATION	DISTANCE (km)
11	0.28	16	0.78
12	0.69	17	0.66
13	0.43	18	0.64
14	0.60	19	0.44
15	0.04	20	0.45

Block mean arsenic concentrations in Snow Lake sediments varied from 21.6 and 34.4 µg/g at the control and outlet blocks respectively, to 112.9 µg/g at block "B" (Table 4). Although these means were not significantly different at F0.95 (Table 4), the great range within block "B" sediment samples (8.0 µg/g to 470.0 µg/g, Appendix 3) suggested that the high variance may have led to a type beta statistical error. Confirmation of the error was indicated by a significant correlation (r^2=0.504) between sediment arsenic concentrations and distance from the mouth of Canada Creek for the exponential regression µg/g As = 0.64 exp.-0.004(km) (Table 5). Thus, as suggested by the water column data, Canada Creek flow appears to have transported arsenic to Snow Lake.

Cadmium was detected at minimal levels in 90% of the sediment samples from Snow Lake (Appendix 3). Block means, which showed a tendency to decrease from blocks "A" to "C", were significantly different at F0.95 (Table 4). However, as the range between the means was only 0.8 µg/g and, as a correlation between sediment concentrations and proximity to the mouth of Canada Creek was not observed (Table 5), it was apparent that cadmium concentrations in Snow Lake sediments were natural and not related to flows from Canada Creek.

Copper concentrations in Snow Lake sediments followed a pattern similar to that of copper concentrations in the water column. Block means tended to decrease from A to C (Table 4). A significant correlation was not observed between concentrations in sediments and proximity to the mouth of Canada Creek (Table 5). Thus there were no

indications that Canada Creek flows had transported significant amounts of copper to Snow Lake.

The pattern of sediment nickel concentrations did not parallel water column concentrations. In both instances block means were not significantly different (Tables 3 and 4). Unlike the water column, block "B" sediment nickel concentrations were not significantly correlated to proximity to the mouth of Canada Creek (Table 5).

Block mean manganese concentrations in sediments differed significantly at F0.95 (Table 4). Mean concentrations were greatest at block "B" (765.8 µg/g, Table 4) and lowest at the outlet, block "C" (228.6 µg/g, Table 4). A correlation was not observed between proximity to the mouth of Canada Creek and manganese concentrations in sediments (Table 5). Thus manganese levels appeared to be natural and block differences may have been due to little understood depth dependent factors of nodule formation (Fairbridge, 1972).

Cyanide was not detected in any of the sediment samples (Table 6) likely because of its instability in the presence of metallic ions. This paralleled the situation in the water column.

b) Herblet Lake

Block mean concentrations of mercury, cadmium, lead and zinc in Herblet Lake sediments were not significantly different at F0.95 (Table 6). Furthermore, correlations between sediment concentrations for these metals and proximity to the mouth of Tailings Creek were not significant (Table 7). Like the situation in the water column, there

TABLE 6: SUMMARY AND ANALYSIS OF VARIANCE OF HERBLET LAKE SEDIMENT DATA

SAMPLING BLOCK	PARAMETER / STATISTIC*	Hg (wet) (µg/g)	Hg (µg/g)	As (µg/g)	Cd (µg/g)	Cu (µg/g)	Pb (µg/g)	Ni (µg/g)	Zn (µg/g)	Fe (%)	Mn (µg/g)	CN (µg/g)
D	$\bar{x}$	< 0.02	< 0.02	11.96	1.0	46.0	24.5	47.5	117.5	2.64	274.9	< 1.0
	δ	0.0	0.0	4.38	0.0	11.7	6.43	17.5	36.1	0.92	101.88	0.0
	Hi	< 0.02	< 0.02	20.7	1.0	60.0	30.0	68.0	155.0	3.54	408.0	< 1.0
	Lo	< 0.02	< 0.02	6.5	< 1.0	30.0	10.0	10.0	85.0	0.31	57.0	< 1.0
E	$\bar{x}$	< 0.02	0.03	273.37	1.0	654.0	27.0	58.0	119.0	2.26	263.2	< 1.0
	δ	0.0	0.032	201.15	0.0	498.05	6.75	14.45	12.87	0.31	25.06	0.0
	Hi	< 0.02	0.12	680.0	1.0	1660.0	35.0	84.0	135.0	2.95	319.0	< 1.0
	Lo	< 0.02	< 0.02	28.0	1.0	50.0	15.0	32.0	90.0	1.71	234.0	< 1.0
F	$\bar{x}$	< 0.02	0.05	19.56	1.0	29.0	24.5	40.6	105.0	3.43	585.2	< 1.0
	δ	0	0.072	19.82	0.0	5.68	7.62	11.5	23.5	0.893	269.3	< 1.0
	Hi	< 0.02	0.19	74.3	1.0	40.0	35.0	65.0	145.0	4.66	1235.0	< 1.0
	Lo	< 0.02	0.02	9.8	< 1.0	20.0	10.0	31.0	85.0	2.48	269.0	< 1.0
ALL	F	0.0	1.49	16.25	0.0	15.32	0.43	3.57	0.88	6.25	11.98	- -
	d.f.	2,27	2,27	2,27	2,27	2,27	2,27	2,27	2,27	2,27	2,27	- -
	F.95	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	- -

*NOTE: $\bar{X}$ = mean
δ = standard deviation
Hi = greatest value
Lo = smallest value

TABLE 7: REGRESSIONS OF BLOCK "E" SEDIMENT METAL CONCENTRATIONS ON DISTANCE * FROM THE MOUTH OF TAILINGS CREEK

Where: µg/g=aexp.b(km)	Hg(dry) (µg/g)	As (µg/g)	Cd (µg/g)	Cu (µg/g)	Pb (µg/g)	Ni (µg/g)	Zn (µg/g)	Fe (%)	Mn (µg/g)
a	0.324	0.374	- -	0.362	0.696	21.381	0.564	3.026	1.536
b	2.545	-0.0002	- -	-0.0001	-0.025	-0.055	-0.004	-0.008	-0.006
r^2	0.020	0.007		0.002	0.092	0.140	0.008	0.022	0.062
$H_0:\beta = 0$ ($t\alpha = 0.05$)	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT	ACCEPT

* Block "E" Station Distances (km) from the Mouth of Tailings Creek:

STATION	DISTANCE (km)	STATION	DISTANCE (km)
11	0.38	16	0.44
12	0.58	17	0.13
13	0.28	18	0.75
14	0.66	19	0.25
15	0.35	20	0.18

were no indications that Tailings Creek flow had transported significant quantities of these metals to Herblet Lake.

Arsenic concentrations in block "E" sediments averaged in excess of one order of magnitude greater than in sediments from either of blocks "D" or "F". This difference was significant at F0.95 (Table 6). However, arsenic levels of block "E" sediments were not significantly correlated to proximity to the mouth of Tailings Creek (Table 7). It was probable that settleable materials emanating from Tailings Creek had been evenly distributed throughout block "E" by the effects of wind action upon the shallow waters of the site. Evidently the area of the sampling block was not large enough to conclude that elevated arsenic levels in block "E" sediments originated from Tailings Creek discharges. This paralleled water column observations.

The status of copper was similar to that of arsenic. Copper concentrations in block "E" sediments also averaged in excess of one order of magnitude greater than in sediments from either of blocks "D" and "F" (Table 6). Additionally, block means for copper differed significantly (Table 6) and correlation between sediment levels in block "E" and proximity to the mouth of Tailings Creek was not significant (Table 7). The absence of a significant correlation was again attributed to the confines of block "E" and wave (wind) dispersal of settleable materials emanating from Tailings Creek. It appeared that elevated copper levels in block "E" sediments were derived from Tailings Creek discharges. The reason for the absence of corroboration from the water column data was not apparent.

Block mean nickel concentrations in Herblet Lake sediments also differed significantly at F0.95 (Table 6). However, the difference between means (i.e. block "E" = 58.0 µg/g Ni; block "F" = 40.6 µg/g Ni; Table 6) was not as pronounced as with either arsenic or copper. Because water column nickel concentrations were not significantly different (Table 3) and as sediment nickel concentrations and proximity to Tailings Creek were not significantly correlated (Table 7), it was unclear whether block "E" sediment nickel levels were natural or the result of Tailings Creek discharges.

Both iron and manganese mean concentrations were significantly greater in block "F" sediments (Table 6). This appeared to be a natural phenomenon.

Like Snow Lake, cyanide concentration were not above the analytical detection limits in any of the sediment samples (Table 6).

BIOACCUMULATION OF METALS

Net set results are detailed in Appendix 5. Appendices 6 and 7 detail metal levels in fish muscle tissue and general meristics for Snow and Herblet Lakes' fish, respectively. These data have been summarized in Tables 8 and 9, respectively. Species metal comparisons between lakes are described in Table 10.

a) Metals in Fish

Regressions of metal levels on weight were calculated for each of the fish species sampled. All but one failed to demonstrate a significant correlation*. Thus it appeared that classic heavy metals bioaccumulation with increments of age or size had not occurred in fish from Snow and Herblet Lakes.

Arsenic showed a strongly consistent pattern when mean metal concentrations in the various fish species sampled were compared on the basis of sample source (Table 10). Each of the three species sampled from Herblet Lake (northern pike, common sucker and cisco) consistently possessed greater mean muscle tissue arsenic concentrations than similar species from Snow, Wekusko or Gods Lake. It was apparent that the elevated arsenic levels in the water column and sediments of block "E" had resulted in significantly elevated levels in fish from Herblet Lake. The arsenic levels in Herblet Lake fish (Table 9) were, however, well within the federally recommended guidelines for human consumption (i.e. <5.0 µg/g As). Excepting the Snow Lake - Wekusko Lake white-fish comparison, fish from Snow Lake were statistically indistinguishable from Wekusko or Gods Lake fish on the basis of arsenic levels (Table 10). The single exception was considered an anomaly. Thus conclusive indications of arsenic impaction upon Snow Lake fish were not observed.

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* A significant correlation (r^2=0.58) for Snow Lake walleye mercury concentrations on weight (g) was observed for the regression µg/g Hg = 2.1×10^{-4} (wt) + 0.05.

Although four instances of significant differences in the fifteen mercury comparisons were noted (Table 10), none of the lakes or species consistently demonstrated signficantly elevated mean mercury concentrations. Mercury is notoriously size and/or age dependent and variations in these parameters were thought to be the source of the distinctions noted. It was concluded that flows from Canada and Tailings Creeks had not caused elevated mercury levels in Snow and Herblet Lake fish. Like arsenic, mean mercury levels in fish muscle tissue were well within federally recommended guidelines (i.e. <0.50 µg/g Hg) for human consumption (Tables 8 and 9).

Cadmium was detected in one common sucker from each of Snow and Herblet Lakes (0.6 µg/g and 0.10 µg/g, respectively, Appendices 6(b) and 7(b)) and in a northern pike from Snow Lake (0.10 µg/g, Appendix 6(a)). Mean concentrations in all instances were below the 0.10 µg/g analytical detection limit and were indistinguishable from those in similar species for Gods and Wekusko Lakes.

Mean copper concentrations in fish from Herblet Lake consistently were significantly lower than in fish from either of Snow or Wekusko Lakes (Table 10). The cause appeared to be related to copper levels in the water column. Copper concentrations in the water column of Snow Lake (Table 1) averaged approximately one order of magnitude greater than those in blocks "D" and "E" of Herblet Lake. Sediment copper levels were not implicated as block "E" mean concentrations (Table 5) were much greater than any in the Snow Lake sediments (Table 4). Because Snow Lake water column copper concentrations were considered unaffected by Canada Creek flows and,

TABLE 8: SUMMARIZATION OF GENERAL MERISTICS AND MUSCLE TISSUE METAL CONCENTRATIONS (WET WEIGHT) OF FISH FROM SNOW LAKE

Species	Fork Length (cm)	Weight (g)	Age (Yrs)	Muscle Tissue Metal Concentrations (µg/g)							Statistic*
				Hg	As	Cd	Cu	Pb	Ni	Zn	
NORTHERN PIKE (N=14;M:F=0.56)	60.6	1805	6.1	0.31	0.07	<0.1	0.47	0.61	0.68	5.5	$\bar{x}$
	9.15	948.7	1.59	0.10	0.07	0	0.17	0.21	0.25	1.43	δ
	75.2	4150	9	0.45	0.26	<0.1	0.80	1.0	1.0	7.7	Hi
	45.0	650	4	0.13	<0.02	<0.1	0.20	<0.5	<0.5	3.8	Lo
COMMON SUCKER (N=17;M:F=2.0)	32.5	531	4.5	0.04	0.05	<0.13	0.43	<0.5	<0.5	4.0	$\bar{x}$
	3.46	160.5	1.18	0.02	0.06	0.12	0.14	0	0	0.49	δ
	38.2	800	6	0.09	0.27	0.6	0.7	0.5	0.5	4.7	Hi
	27.4	310	2	<0.02	<0.02	<0.1	<0.1	<0.5	<0.5	3.0	Lo
LAKE WHITEFISH (N=20;M:F=0.43)	38.4	873	13.9	0.12	0.11	<0.1	0.23	0.55	<0.5	4.1	$\bar{x}$
	3.18	198.9	7.69	0.06	0.07	0	0.12	0.15	0	1.01	δ
	44.2	1220	29	0.25	0.33	<0.1	0.5	1.0	<0.5	7.1	Hi
	32.6	600	6	0.04	0.02	<0.1	0.1	<0.5	<0.5	2.9	Lo
WALLEYE (N=20;M:F=0.67)	40.0	767	6.8	0.21	0.09	<0.1	0.42	<0.51	0.56	4.2	$\bar{x}$
	5.92	336.1	2.97	0.09	0.11	0	0.26	0.02	0.16	0.77	δ
	50.5	1580	17	0.48	0.45	<0.1	1.1	0.7	1.0	6.3	Hi
	30.2	360	4	0.13	<0.2	<0.1	0.1	<0.5	<0.5	3.0	Lo

*NOTE: $\bar{X}$ = mean
δ = standard deviation
Hi = greatest value
Lo = smallest value

TABLE 9: SUMMARIZATION OF GENERAL MERISTICS AND MUSCLE TISSUE METAL CONCENTRATIONS (WET WEIGHT) OF FISH FROM HERBLET LAKE

Species	Length (cm)	Weight (g)	Age (Yrs)	Muscle Tissue Metal Concentrations (µg/g)							Statistic*
				Hg	As	Cd	Cu	Pb	Ni	Zn	
NORTHERN PIKE (N=20;M:F=1.0)	49.5	840	4.7	0.36	0.47	<0.1	0.18	<0.51	<0.53	5.3	$\bar{x}$
	4.84	239	0.75	0.11	0.51	0	0.06	0.02	0.04	1.03	δ
	61.0	1500	6	0.65	2.20	<0.1	0.3	0.6	0.6	8.2	Hi
	42.8	590	3	0.19	0.05	<0.1	<0.1	<0.5	<0.5	3.8	Lo
COMMON SUCKER (N=20;M:F=1.0)	36.5	779	5.0	0.07	0.15	<0.1	0.32	<0.5	<0.52	4.6	$\bar{x}$
	2.64	165.3	1.03	0.03	0.10	0	0.14	0	0.04	0.82	δ
	44.3	1280	7	0.13	0.46	0.1	0.7	0.5	0.8	6.1	Hi
	32.2	540	3	0.03	0.06	<0.1	0.2	<0.5	<0.5	3.3	Lo
CISCO (N=20;M:F=0.46)	29.8	488	5.5	0.12	0.33	<0.1	0.22	<0.5	<0.53	7.6	$\bar{x}$
	2.05	101.5	2.11	0.07	0.09	0	0.06	0	0.09	2.69	δ
	33.5	640	11	0.33	0.55	<0.1	0.4	<0.5	0.8	14.5	Hi
	24.9	260	3	0.04	0.19	<0.1	0.1	<0.5	<0.5	4.8	Lo

*NOTE: $\bar{X}$ = mean
δ = standard deviation
Hi = greatest value
Lo = smallest value

TABLE 10: COMPARISONS ($t_{\alpha}=0.05$) OF MUSCLE TISSUE METAL LEVELS IN FISH FROM SNOW, HERBLET, WEKUSKO AND GODS LAKE

Species	Lake vs. Lake	Lake[1] with Significantly Greater Level ($t_{\alpha}=0.05$)						
		Hg	As	Cd	Cu	Pb	Ni	Zn
Northern Pike	Snow - Herblet	—	He	—	Sn	Sn	Sn	—
	Snow - Wekusko[2]	—	—	—	—	—	—	—
	Snow - Gods[3]	—	—	—	—	—	—	—
	Herblet - Wekusko[2]	He	He	—	We	We	—	We
	Herblet - Gods[3]	—	He	—	—	—	—	—
Common Sucker	Snow - Herblet	He	He	—	Sn	—	He	He
	Snow - Wekusko[2]	We	—	—	—	We	We	—
	Snow - Gods[3]	—	—	—	—	—	—	—
	Herblet - Wekusko[2]	—	He	—	We	We	—	He
	Herblet - Gods[3]	—	He	—	—	—	—	—
Whitefish	Snow - Wekusko[2]	Sn	Sn	—	We	We	We	—
	Snow - Gods[3]	—	—	—	—	—	—	—
Walleye	Snow - Wekusko[2]	—	—	—	—	We	—	—
	Snow - Gods[3]	—	—	—	Sn	—	—	—
Cisco	Herblet - Wekusko[2]	—	He	—	We	We	—	—

1. Abbreviations as follows: Sn = Snow Lake; He = Herblet Lake; We - Wekusko Lake; Go = Gods Lake; "—" No significant difference.

2. Means for this species extracted from Brown et al, 1980.

3. Means for this species extracted from Beck, 1982.

as Wekusko Lake fish possessed copper levels similar to those from Snow Lake, the matter was considered not attributable to Canada Creek flows.

Excepting northern pike, fish from Snow Lake were indistinguishable from those of either Herblet or Gods Lakes on the basis of mean muscle tissue lead concentrations (Table 10). They consistently demonstrated significantly lower lead levels than did fish from Wekusko Lake. Because Snow Lake pike were indistinguishable from either of Gods or Wekukso Lake pike (Table 10), it was concluded that flows from Canada and/or Tailings Creek had not significantly affected fish muscle tissue lead levels in fish from either Snow Lake or Herblet Lake.

Neither nickel nor zinc comparisons yielded consistently significant differences (Table 10). It was concluded that flows from Canada and Tailings Creek were not significantly affecting muscle tissue concentrations of these metals in the fish of Snow and Herblet Lakes.

THE ORE CONCENTRATE STOCKPILE

The stockpiled concentrate is located immediately north of the present Snow Lake mine superstructure (Figure 4). It consists of 226,800 tonnes of arsenical concentrate averaging 7.9 g/tonne gold (Mineral Development Sector, 1973). Surficial arsenic concentrations at the stockpile (Stations 3 and 4, Figure 4) averaged 8.4% whereas other metals were considerably more dilute (Table 11). Surficial stockpile cyanide concentrations were low in comparison to downstream concentrations (Station 1 and 2, Figure 4).

Drainage from the stockpile area appeared to be of an intermittent nature as flow channels were not clearly defined. The probable course of drainage (Figure 4) meandered westerly to Canada Creek. Ponded water was encountered only in a minor depression at sampling site #1 (Figure 4). The chemistry of this ponded water was typical of dilute mine drainage as conductivity was elevated, pH was depressed and alkalinities were undetectable (Table 12). This indicated that some surficial inflows from the stockpile site had occurred.

Analytical data concerning the stockpile (Table 11) generally substantiated previously discussed conclusions pertaining to Snow Lake. Levels of cadmium, copper, iron, lead, mercury and zinc were all relatively low and likely could not detrimentally impact Snow Lake. Although Snow Lake water column nickel concentrations appeared affected by flows from Canada Creek, drainage from the stockpile did not appear to be the source of nickel loadings. Canada Creek loadings of arsenic to the water column and sediments of Snow Lake appeared to have originated with drainage from the stockpile as levels varied from 0.85% to 8.54% (Table 11).

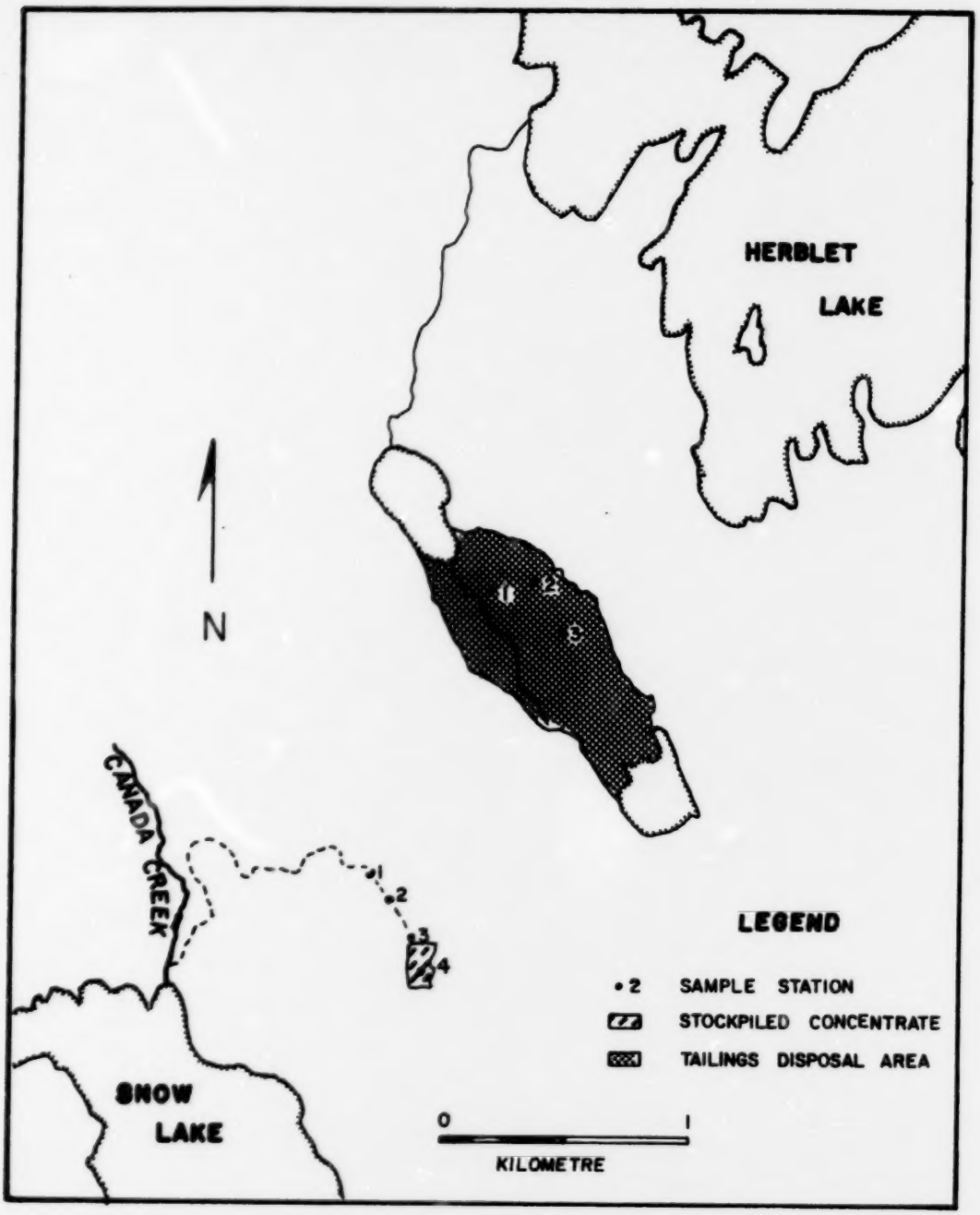

Figure 4. Site of the Stockplied Concentrate and Tailings Disposal Area.

TABLE 11: SURFICIAL METAL AND CYANIDE CONCENTRATIONS (DRY WEIGHT) IN THE VICINITY OF THE ORE CONCENTRATE STOCKPILE

Parameter \ Station*	1	2	3	4
Hg (µg/g)	0.11	0.08	0.10	0.13
As (mg/g)	8.52	50.0	83.7	85.4
Cd (µg/g)	<1.0	1.0	3.0	3.0
Cu (µg/g)	700	590	940	530
Pb (µg/g)	25	40	100	70
Ni (µg/g)	26	26	29	26
Zn (µg/g)	55	120	110	25
Fe (µg/g)	82.6	165	171	183
Mn (µg/g)	55	129	92	107
CN (µg/g)	280	240	8.0	7.0

*Sampling stations as per Figure 4.

TABLE 12: RESULTS OF CHEMICAL ANALYSIS OF PONDED WATERS FROM THE SNOW LAKE ORE CONCENTRATE STOCKPILE DRAINAGE PATH AND THE BIRCH LAKE TAILINGS AREA

Parameter \ Site*	Ore Stockpile Drainage Path at #1	Birch Lake Tailings Area at #1
Conductivity µS/cm)	1610	689
Residue Non. Filt. (mg/L)	11.0	<5.0
pH (units)	3.25	8.15
Total Alkalinity (mg/L $CaCO_3$)	0.0	120
Alkalinity (mg/L HCO_3)	0.0	146
Alkalinity (mg/L CO_3)	0.0	0.0
Alkalinity (mg/L OH)	0.0	0.0
Total Organic Carbon (mg/L)	15.5	24.0
Total Inorganic Carbon (mg/L)	3.5	21.5
Turbidity (NTU)	100	4.0
Total Kjeldhal N (mg/L)	0.9	1.2
Diss. NO_3-NO_2 (mg/L)	<0.01	<0.01
Total P (mg/L)	0.07	2.0
Total CN (mg/L)	<0.02	<0.02
Free CN (mg/L)	<0.02	<0.02
As - total (mg/L)	0.150	1.78
Cd - ext. (mg/L)	<0.005	<0.005
Cu - ext. (mg/L)	0.10	0.044
Pb - ext. (mg/L)	0.005	<0.005
Ni - ext. (mg/L)	0.30	<0.005
Zn - ext. (mg/L)	0.96	0.02
Ca - ext. (mg/L)	128	88
Mg - ext. (mg/L)	73	18
Hg - total (µg/L)	<0.02	<0.02

*Sites as per Figure 4.

THE BIRCH LAKE TAILINGS DISPOSAL AREA

The Birch Lake tailings disposal area is located 1.0 kilometres north-west of the present Snow Lake mine superstructure (Figure 4). Including ponded waters at both the north and south ends, the tailings encompass an area of approximately 0.69 square kilometres. The area is utilized both as a landing strip for light aircraft and as a course by local golfers. Additionally, the site had received discharges from the Town's sewage treatment facility.

The topography of the area is such that little runoff enters the tailings site from surrounding areas. The bulk of drainage from the site originates with precipitation falling directly on the tailings and with minor sewage discharges. Runoff accumulates primarily at the lower (north) end of the tailings and then drains northeast through a bog to the Southwest Bay of Herblet Lake.

Samples of ponded waters at the lower (north) end of the tailings (Figure 4) were atypical of normal tailings drainage (Table 11). As discussed with Herblet Lake water quality, the sewage discharges to the tailings area resulted in elevated pH, alkalinities, carbons and nutrients. Apart from arsenic and copper, the alkaline nature of the drainage appears to have prevented massive dissolution and transport of metals.

Surficial metal concentrations in the tailings were similar to those of the ore concentrate stockpile. Most metals were considerably more dilute than arsenic (mean 0.47%; Table 13). Cyanide appeared to be unevenly distributed as only one of three samples yielded detectable concentrations (Table 13). Surficial metal concentrations and analytical results from ponded waters appeared to confirm previously discussed conclusions pertaining to Herblet Lake.

TABLE 13: SURFICIAL METAL AND CYANIDE CONCENTRATIONS (DRY WEIGHT) IN THE VICINITY OF THE BIRCH LAKE TAILINGS DISPOSAL AREA

Parameter \ Station*	1	2	3
Hg (µg/g)	0.03	<0.02	<0.02
As (mg/g)	2.04	7.02	4.91
Cd (µg/g)	1.0	<1.0	<1.0
Cu (µg/g)	50	90	60
Pb (µg/g)	15	20	20
Ni (µg/g)	26	42	26
Zn (µg/g)	50	50	40
Fe (µg/g)	32.5	39.5	31.3
Mn (µg/g)	595	644	573
CN (µg/g)	120	<2.0	<2.0

*Sampling stations as per Figure 4.

CONCLUSIONS

The following conclusions have been formulated with respect to Snow Lake and the ore concentrate stockpile.

1. Drainage from the ore concentrate stockpile was the source of elevated arsenic levels in the water column and sediments of Snow Lake.
2. Mean arsenic levels in the water column of Snow Lake (0.004 mg/L) were well below the federally recommended maximum acceptable concentration of 0.05 mg/L.
3. Drainage from the ore concentrate stockpile had not impacted upon the pH of Snow Lake or upon water column and sediment concentrations of cyanide, cadmium, copper, lead, mercury, nickel and zinc.
4. Drainage from the ore concentrate stockpile had not detectably affected bioaccumulation of metals by fish in Snow Lake.

The following conclusions have been formulated with respect to Herblet Lake and the Birch Lake tailings disposal area.

1. Drainage from the Birch Lake tailings disposal area was the source of elevated arsenic levels in the water column and sediments of Herblet Lake's southwest bay.
2. Drainage from the Birch Lake tailings disposal area was the source of elevated copper levels in the sediments of Herblet Lake's southwest bay.

3. Drainage from the Birch Lake tailings disposal area had caused a moderate alkalization of the waters of Herblet Lake's southwest bay.
4. Drainage from the Birch Lake tailings disposal area had not impacted upon Herblet Lake water column and sediment concentrations of cyanide, cadmium, lead, mercury, nickel and zinc.
5. Drainage from the Birch Lake tailings disposal area resulted in elevated arsenic levels in the muscle tissue of Herblet Lake fish.
6. Apart from arsenic, drainage from the Birch Lake tailings disposal area had not detectably affected bioaccumulation of metals by fish in Herblet Lake.

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APPENDIX

APPENDIX 1(a): SNOW LAKE PHYSIOCHEMICAL DATA, SAMPLING BLOCK "A" (JULY 9, 1981)

SAMPLING BLOCK		"A"													
PARAMETER \ STATION		1	2	3	4	5	6	7	8	9	10				
Field Temperature	°C	19.0	19.0	19.0	19.0	10.0	19.0	19.0	13.0	15.0	19.0				
Conductivity	µs/cm	105.	105.	105.	105.	110.	105.	106.	110.	105.	110.				
Residue Nonfilterable	mg/L	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0				
pH (units)		7.55	7.45	7.45	7.45	6.75	7.55	7.50	6.90	7.50	6.90				
Alkalinity Total ($CaCO_3$)	mg/L	48.75	48.2	48.6	48.2	50.2	48.8	199.0	50.0	48.2	48.8				
Alkalinity (HCO_3)	mg/L	59.5	58.9	59.4	58.9	61.2	59.5	243.0	61.0	58.9	59.5				
Alkalinity (CO_3)	mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Alkalinity (OH)	mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Dissolved Oxygen	mg/L	7.7	8.0	7.2	7.6	0.3	7.9	11.9	1.6	7.6	2.2				
T.O.C.	mg/L	18.5	18.5	18.0	18.5	17.5	19.0	17.5	17.5	18.5	17.0				
T.I.C.	mg/L	10.0	10.0	9.5	10.0	12.0	9.5	12.0	11.5	8.0	10.5				
Turbidity	NTU	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -				
Kjeldhal Total N	mg/L	0.6	0.5	0.6	0.5	0.7	0.5	0.5	0.5	0.5	0.5				
NO_3-NO_2-N (Dissolved)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01				
P Total	mg/L	0.03	0.08	0.02	0.03	0.16	0.03	0.03	0.06	0.03	0.06				
Cyanide Total	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02				
Cyanide Free	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02				
As (Total)	mg/L	0.003	0.003	0.002	0.002	0.004	0.003	0.003	0.004	0.002	0.002				
Cd (Ext)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005				
Cu (Ext)	mg/L	0.07	0.07	0.006	0.027	<0.005	0.006	0.013	<0.005	0.034	0.032				
Pb (Ext)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005				
Ni Ext	mg/L	<0.005	<0.005	0.006	0.012	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005				
Zn (Ext) (Dis)	mg/L	0.02	0.02	<0.02	<0.02	<0.02	0.03	0.02	<0.02	<0.02	0.02				
Ca (Ext)	mg/L	13.	13.	13.	13.	13.	13.	12.	10.	10.	10.				
Mg (Ext)	mg/L	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.				
Hg Total	µg/L	<0.02	- -	<0.02	- -	- -	- -	- -	- -	- -	- -				
Sampling Depth/Total Depth (m)		0.2/8.2	1.5/5.0	0.3/2.0	1.3/7.2	11./12.	1.1/10.0	2.8/11.1	8.6/9.5	6.0/11.8	7.8/10.3				

APPENDIX 1(b) SNOW LAKE PHYSICOCHEMICAL DATA, SAMPLING BLOCK "B" (JULY 9, 1981)

SAMPLING BLOCK		"B"													
PARAMETER \ STATION		11	12	13	14	15	16	17	18	19	20				
Field Temperature	°C	19.0	19.0	19.0	13.0	19.0	19.0	19.0	19.0	19.0	19.0				
Conductivity	µS/cm	111.	111.	117.	117.	132.	117.	111.	116.	116.	116.				
Residue Nonfilterable	mg/L	<5.0	<5.0	5.0	<5.0	<5.0	7.0	<5.0	<5.0	<5.0	<5.0				
pH (units)		7.85	7.80	7.90	7.00	7.55	7.80	7.90	7.75	7.60	7.65				
Alkalinity Total ($CaCO_3$)	mg/L	51.8	51.8	52.5	51.5	60.5	53.8	51.5	51.5	51.8	51.8				
Alkalinity (HCO_3)	mg/L	63.1	63.1	64.0	62.8	73.8	65.6	62.8	62.8	63.1	63.1				
Alkalinity (CO_3)	mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Alkalinity (OH)	mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Dissolved Oxygen	mg/L	8.1	7.9	8.6	2.8	6.8	- -	8.1	8.4	7.7	7.2				
T.O.C.	mg/L	17.5	16.5	16.5	15.5	18.5	16.5	16.5	17.0	17.0	17.0				
T.I.C.	mg/L	9.5	9.5	9.0	11.5	12.0	8.5	7.0	7.0	8.5	9.0				
Turbidity	NTU	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -				
Kjeldhal Total N	mg/L	0.5	0.5	0.6	0.5	0.6	0.5	0.5	0.5	0.6	0.6				
NO_3-NO_2-N (Dissolved)	mg/L	<0.01	<0.01	0.02	0.08	<0.01	<0.01	<0.01	0.01	<0.01	0.01				
P Total	mg/L	0.03	0.04	0.04	0.05	0.05	0.04	0.03	0.04	0.03	0.03				
Cyanide Total	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02				
Cyanide Free	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02				
As (Total)	mg/L	0.004	0.004	0.005	0.004	0.017	0.004	0.005	0.004	0.004	0.003				
Cd (Ext)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005				
Cu (Ext)	mg/L	<0.005	<0.005	0.029	0.006	0.014	0.013	0.016	0.037	<0.005	<0.005				
Pb (Ext)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005				
Ni Ext	mg/L	0.045	0.006	<0.005	<0.005	0.036	<0.005	0.008	<0.005	<0.005	<0.005				
Zn (Ext) (Dis)	mg/L	<0.02	<0.02	0.02	<0.02	<0.02	0.02	<0.02	0.02	0.02	<0.02				
Ca (Ext)	mg/L	13.	13.	13.	13.	15.	13.	13.	13.	13.	13.				
Mg (Ext)	mg/L	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.				
Hg Total	µg/L	<0.02	- -	- -	- -	<0.02	- -	<0.02	- -	- -	- -				
Sampling Depth/Total Depth(m)		0.6/8.8	3.7/4.0	2.5/4.0	9.7/11.5	0.7/1.0	6.9/12.5	0.4/4.2	2.5/9.0	4.7/13.0	5.1/12.2				

APPENDIX 1(p) SNOW LAKE PHYSICOCHEMICAL DATA, SAMPLING BLOCK "C" (JULY 9, 1981)

SAMPLING BLOCK	"C"													
PARAMETER / STATION	21	22	23	24	25	26	27	28	29	30				
Field Temperature °C	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0				
Conductivity µ℧/cm	117.	111.	112.	113.	115.	112.	116.	116.	116.	116.				
Residue Nonfilterable mg/L	10.	8.0	19.0	26.0	12.0	9.0	10.0	7.0	10.0	14.0				
pH (units)	7.95	7.80	8.00	7.85	7.90	7.90	7.80	7.85	7.90	7.80				
Alkalinity Total ($CaCO_3$) mg/L	51.8	51.2	51.8	52.5	52.5	51.2	51.5	51.5	51.5	51.2				
Alkalinity (HCO_3) mg/L	63.1	62.5	63.1	64.0	64.0	62.5	62.8	62.8	62.8	62.5				
Alkalinity (CO_3) mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Alkalinity (OH) mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Dissolved Oxygen mg/L	8.0	8.2	8.4	8.4	8.3	8.9	7.9	8.5	8.4	7.2				
T.O.C. mg/L	18.5	18.5	19.5	19.0	17.0	17.5	18.5	18.5	17.5	17.5				
T.I.C. mg/L	7.5	9.5	8.5	8.0	8.0	8.5	7.5	7.0	5.5	8.5				
Turbidity NTU	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -				
Kjeldhal Total N mg/L	0.6	0.5	0.5	0.5	0.6	0.5	0.6	0.6	0.6	0.6				
NO_3-NO_2-N (Dissolved) mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01				
P Total mg/L	0.03	0.04	0.07	0.05	0.04	0.04	0.04	0.05	0.04	0.04				
Cyanide Total mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02				
Cyanide Free mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02				
As (Total) mg/L	0.004	0.004	0.005	0.005	0.004	0.004	0.004	0.005	0.005	0.005				
Cd (Ext) mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005				
Cu (Ext) mg/L	0.039	0.015	0.008	<0.005	0.018	0.040	0.027	<0.005	0.013	0.005				
Pb (Ext) mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.010	<0.005	<0.005	<0.005				
Ni Ext mg/L	0.008	<0.005	0.030	0.009	<0.005	<0.005	<0.005	<0.005	0.029	<0.005				
Zn (Ext) (Dis) mg/L	0.05	<0.02	0.02	0.02	0.02	<0.02	0.06	<0.02	<0.02	<0.02				
Ca (Ext) mg/L	14.	13.	13.	15.	18.	18.	18.	18.	18.	18.				
Mg (Ext) mg/L	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.				
Hg Total µg/L	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -				
Sampling Depth/Total Depth (m)	2.1/2.3	1.4/2.5	1.5/1.8	2.4/2.5	2.5/2.8	1.2/2.0	0.7/2.0	2.4/2.5	1.8/2.5	0.6/2.5				

APPENDIX 2(a) HERBERT LAKE PHYSICOCHEMICAL DATA, SAMPLING BLOCK "D" (JULY 7, 1981)

SAMPLING BLOCK		"D"													
PARAMETER \ STATION		1	2	3	4	5	6	7	8	9	10				
Field Temperature	°C	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0				
Conductivity	µS/cm	98.0	98.0	97.0	96.0	98.0	97.0	97.0	97.0	96.0	97.0				
Residue Nonfilterable	mg/L	<5.0	5.0	<5.0	5.0	<5.0	<5.0	<5.0	5.0	7.0	<5.0				
pH units		7.80	7.65	7.70	7.70	7.70	7.60	7.65	7.70	7.65	7.55				
Alkalinity Total ($CaCO_3$)	mg/L	40.0	40.0	40.0	40.0	40.5	40.0	40.5	40.0	40.0	39.25				
Alkalinity (HCO_3)	mg/L	49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0	47.9				
Alkalinity (CO_3)	mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Alkalinity (OH)	mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Dissolved Oxygen	mg/L	8.0	8.3	8.2	8.1	7.7	8.4	8.2	7.9	8.0	8.1				
T.O.C.	mg/L	15.0	15.5	14.5	14.5	17.0	15.0	16.5	15.5	15.0	16.0				
T.I.C.	mg/L	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0				
Turbidity	NTU	2.5	2.0	2.0	2.0	3.0	3.0	2.5	1.5	3.0	2.0				
Kjeldhal Total N	mg/L	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6				
NO_3-NO_2-N (Dissolved)	mg/L	<0.01	<0.01	0.01	0.01	<0.01	<0.01	0.01	<0.01	0.04	0.01				
P Total	mg/L	0.03	0.07	0.04	0.02	0.04	0.04	0.02	0.02	0.05	0.04				
Cyanide Total	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02				
Cyanide Free	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02				
As (Total)	mg/L	0.005	0.004	0.004	0.004	0.003	0.004	0.005	0.005	0.004	0.005				
Cd (Ext)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<<0.005	<0.005	<0.005				
Cu (Ext)	mg/L	<0.005	<0.005	0.010	0.005	0.005	0.005	0.005	0.005	0.005	0.005				
Pb (Ext)	mg/L	0.005	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005				
Ni Ext	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005				
Zn (Ext) (Dis)	mg/L	<0.02	<0.02	<0.02	:0.02	<0.02	<0.02	<0.02	0.02	0.02	0.02				
Ca (Ext)	mg/L	13.0	13.0	13.0	13.0	13.0	13.0	10.0	13.	13.	10.				
Mg (Ext)	mg/L	4.5	4.3	4.3	4.3	4.3	4.3	4.3	4.4	4.5	4.3				
Hg Total	µg/L	<0.02	<0.02	<0.02	- -	- -	- -	- -	- -	- -	- -				
Sampling Depth/Total Depth(m)		0.1/2.4	0.5/2.0	0.5/2.7	1.5/3.2	1.9/2.3	1.2/3.1	2.3/3.2	1.2/2.3	2.9/3.1	1.6/3.1				

APPENDIX 2(b) HEWLET LAKE PHYSIOCHEMICAL DATA, SAMPLING BLOCK "E" (JULY 7, 1981)

SAMPLING BLOCK	"E"													
PARAMETER / STATION	11	12	13	14	15	16	17	18	19	20				
Field Temperature °C	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0				
Conductivity µS/cm	108.	105.	109.	107.	110.	108.	106.	109.	108.	108.				
Residue Nonfilterable mg/L	<5.0	7.0	6.0	5.0	8.0	<5.0	7.0	6.0	8.0	11.0				
pH (units)	7.80	7.90	7.95	7.80	7.85	8.00	8.40	7.90	7.80	7.90				
Alkalinity Total ($CaCO_3$) mg/L	40.5	41.0	41.0	41.0	41.5	41.0	41.5	41.5	40.5	41.5				
Alkalinity (HCO_3) mg/L	49.0	50.0	50.0	50.0	51.0	50.0	50.0	51.0	49.0	51.0				
Alkalinity (CO_3) mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0				
Alkalinity (OH) mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Dissolved Oxygen mg/L	8.3	9.0	8.1	8.0	—	8.7	9.2	8.9	9.0	8.2				
T.O.C. mg/L	20.5	19.5	20.0	19.5	20.0	20.0	19.0	19.5	19.0	19.5				
T.I.C. mg/L	9.5	9.0	9.0	8.5	9.0	9.0	8.0	9.0	8.5	8.5				
Turbidity NTU	4.0	3.5	3.5	3.0	3.5	4.0	4.0	3.0	3.5	3.5				
Kjeldhal Total N mg/L	0.8	0.8	0.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8				
NO_3-NO_2-N (Dissolved) mg/L	<0.01	<0.01	<0.01	<0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01				
P Total mg/L	0.07	0.08	0.08	0.08	0.08	0.09	0.07	0.05	0.08	0.10				
Cyanide Total mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02				
Cyanide Free mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02				
As (Total) mg/L	0.045	0.038	0.048	0.045	0.043	0.050	0.039	0.046	0.039	0.046				
Cd (Ext) mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005				
Cr (Ext) mg/L	0.015	0.010	0.005	0.010	0.005	0.005	0.005	0.005	0.005	0.005				
Pb (Ext) mg/L	0.005	0.005	0.005	0.005	0.005	0.005	<0.005	0.005	<0.005	0.005				
Ni Ext mg/L	0.005	<0.005	0.005	0.005	0.005	0.005	0.005	0.010	0.005	0.005				
Zn (Ext) (Dis) mg/L	<0.02	0.02	0.02	<0.02	<0.02	<0.02	<0.02	0.02	0.02	0.02				
Ca (Ext) mg/L	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0				
Mg (Ext) mg/L	5.0	5.0	4.7	4.5	4.8	4.5	4.5	4.5	5.0	5.0				
Hg Total µg/L	- -	<0.02	- -	<0.02	- -	- -	- -	<0.02	- -	- -				
Sampling Depth/Total Depth (m)	0.6/1.5	0.1/1.8	0.7/1.6	0.1/1.9	1.2/2.0	0.6/1.7	0.7/1.0	0.4/1.9	1.1/1.5	1.2/1.6				

APPENDIX 2(c) HERBERT LAKE PHYSIOCHEMICAL DATA, SAMPLING BLOCK "F" (JULY 7.1981)

SAMPLING BLOCK		"F"													
PARAMETER \ STATION		21	22	23	24	25	26	27	28	29	30				
Field Temperature	°C	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0				
Conductivity	µS/cm	78.5	78.5	80.8	77.8	78.8	80.8	79.6	79.6	78.5	78.5				
Residue Nonfilterable	mg/L	7.0	<5.0	6.0	8.0	6.0	7.0	<5.0	<5.0	<5.0	6.0				
pH (units)		7.20	7.35	7.18	7.35	7.18	7.19	7.15	7.20	7.45	7.45				
Alkalinity Total ($CaCO_3$)	mg/L	32.25	32.0	32.85	33.65	32.75	33.25	32.25	33.75	32.45	32.65				
Alkalinity (HCO_3)	mg/L	39.3	39.0	40.1	41.0	40.0	40.7	39.0	41.2	39.6	39.8				
Alkalinity (CO_3)	mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Alkalinity (OH)	mg/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Dissolved Oxygen	mg/L	6.4	7.2	4.5	6.8	7.0	6.0	5.8	8.1	6.1	7.1				
T.O.C.	mg/L	16.5	16.5	15.5	15.0	16.0	15.5	14.5	16.0	15.0	14.5				
T.I.C.	mg/L	7.0	7.5	7.5	7.5	7.0	8.0	8.0	8.0	7.5	7.5				
Turbidity	NTU	3.5	2.5	3.0	2.0	3.0	3.0	2.0	2.0	2.5	2.0				
Kjeldhal Total N	mg/L	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6				
NO_3-NO_2-N (Dissolved)	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01				
P Total	mg/L	0.08	0.06	0.06	0.05	0.05	0.05	0.06	0.04	0.04	0.04				
Cyanide Total	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02				
Cyanide Free	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02				
As (Total)	mg/L	0.006	0.004	0.006	0.003	0.003	0.003	0.004	0.003	0.004	0.004				
Cl (Ext)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005				
Cu (Ext)	mg/L	0.005	0.110	0.035	0.005	0.005	0.080	0.005	0.005	<0.005	0.005				
Pb (Ext)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005				
Ni Ext	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005				
Zn (Ext) (Dis)	mg/L	<0.02	0.03	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	0.02	<0.02				
Ca (Ext)	mg/L	8.0	8.0	10.0	10.0	8.0	10.0	10.0	10.0	10.0	8.0				
Mg (Ext)	mg/L	3.5	3.3	3.8	3.8	3.5	3.5	3.5	3.5	3.5	3.3				
Hg Total	µg/L	- -	- -	- -	- -	- -	- -	<0.02	- -	- -	<0.02				
Sampling Depth/Total Depth (m)		1.4/1.5	1.0/1.8	1.4/1.6	1.5/1.5	1.4/1.5	1.1/1.9	0.4/1.0	1.5/1.5	0.9/1.25	0.3/1.4				

APPENDIX 3 : Metal Concentrations* in Snow Lake Sediments

Parameter / Station	Hg (wet) (µg/g)	Hg (µg/g)	As (µg/g)	Cd (µg/g)	Ca (µg/g)	Pb (µg/g)	Ni (µg/g)	Zn (µg/g)	Fe (%)	Mn (µg/g)	CN (µg/g)
1	< 0.02	0.02	14.0	1.0	60.0	< 5.0	5.0	40.0	0.71	131.	
2	< 0.02	0.02	19.0	<1.0	90.0	10.0	5.0	50.0	0.47	178.	
3	< 0.02	0.02	7.4	1.0	50.0	10.0	5.0	30.0	0.38	141.	
4	0.02	0.08	24.0	2.0	100.0	5.0	39.0	135.0	3.19	643.	
5	0.02	0.12	17.0	2.0	100.0	40.0	42.0	140.0	0.33	549.	< 2.0
6	0.03	0.15	32.0	2.0	90.0	40.0	42.0	140.0	3.25	550.	
7	< 0.02	0.05	19.0	2.0	90.0	30.0	39.0	135.0	0.33	574.	
8	0.02	0.09	13.0	2.0	100.0	35.0	42.0	140.0	3.36	602.	
9	0.03	0.16	37.0	2.0	80.0	40.0	42.0	120.0	3.19	520.	
10	0.02	0.07	34.0	3.0	100.0	35.0	39.0	140.0	3.25	530.	< 2.0
11	0.02	0.05	47.0	1.0	60.0	20.0	21.0	80.0	1.95	332.	
12	< 0.02	0.02	16.0	2.0	30.0	45.0	52.0	120.0	1.18	1855.	
13	< 0.02	<0.02	8.0	1.0	<1.0	15.0	5.0	20.0	0.41	123.	
14	0.03	0.11	39.0	2.0	100.0	35.0	47.0	145.0	3.78	585.	
15	0.02	0.09	470.0	1.0	50.0	20.0	21.0	65.0	1.59	560.	< 2.0
16	0.03	0.12	52.0	1.0	90.0	45.0	47.0	150.0	3.84	597.	
17	< 0.02	<0.02	60.0	<1.0	60.0	20.0	10.0	55.0	0.74	260.	
18	0.02	0.03	330.0	1.0	30.0	40.0	42.0	95.0	1.89	1388.	
19	0.03	0.12	58.0	2.0	60.0	55.0	50.0	175.	3.89	555.	
20	0.02	0.10	49.0	2.0	100.0	55.0	47.0	190.0	3.48	503.	< 2.0
21	0.02	0.16	32.0	1.0	110.0	25.0	44.0	110.0	1.71	263.	
22	0.02	0.12	40.0	1.0	50.0	25.0	52.0	110.0	2.01	270.	
23	0.02	0.03	10.0	<1.0	20.0	10.0	18.0	35.0	0.77	75.	
24	< 0.02	0.04	36.0	1.0	50.0	30.0	63.0	110.0	2.01	270.	
25	0.02	0.13	73.0	1.0	50.0	25.0	58.0	90.0	1.95	263.	< 2.0
26	0.02	0.13	25.0	1.0	60.0	25.0	47.0	100.0	1.83	257.	
27	< 0.02	0.08	36.0	1.0	40.0	20.0	47.0	80.0	1.48	200.	
28	0.02	0.12	24.0	1.0	30.0	20.0	26.0	70.0	1.18	169.	
29	0.02	0.17	39.0	1.0	50.0	20.0	47.0	100.0	1.95	292.	
30	0.02	0.12	29.0	1.0	50.0	25.0	47.0	100.0	1.65	227.	< 2.0

* Based on dry weight of sample except where indicated.

APPENDIX 4 : Metal Concentrations* in Herblet Lake Sediment

Parameter / Station	Hg (wet) (µg/g)	Hg (µg/g)	As (µg/g)	Cd (µg/g)	Cu (µg/g)	Pb (µg/g)	Ni (µg/g)	Zn (µg/g)	Fe (%)	Mn (µg/g)	CN (µg/g)
1	<0.02	<0.02	14.0	1.0	40.0	25.0	47.0	120.0	3.01	408.	
2	<0.02	<0.02	6.5	1.0	30.0	20.0	37.0	90.0	2.18	220.	
3	<0.02	<0.02	12.0	1.0	60.0	30.0	52.0	155.	2.66	276.	
4	<0.02	<0.02	8.9	<1.0	50.0	10.0	10.0	40.0	2.95	57.	
5	<0.02	<0.02	7.4	<1.0	40.0	25.0	52.0	130.	3.36	350.	<1.0
6	<0.02	<0.02	8.5	<1.0	30.0	20.0	31.0	85.0	2.36	232.	
7	<0.02	<0.02	13.0	1.0	40.0	25.0	52.0	120.0	3.10	234.	
8	<0.02	<0.02	20.7	1.0	50.0	30.0	63.0	150.0	3.54	400.	
9	<0.02	<0.02	12.3	1.0	60.0	30.0	68.0	145.0	3.01	277.	
10	<0.02	<0.02	16.3	1.0	60.0	30.0	63.0	140.0	3.01	295.	<1.0
11	<0.02	<0.02	390.0	1.0	770.0	30.0	58.0	125.0	2.12	270.	
12	<0.02	<0.02	220.0	1.0	530.0	25.0	55.0	125.0	2.24	248.	
13	<0.02	<0.02	52.7	1.0	50.0	15.0	32.0	90.0	1.71	286.	
14	<0.02	<0.02	385.	1.0	900.0	20.0	63.0	110.0	2.30	265.	
15	<0.02	<0.02	350.	1.0	840.0	30.0	68.0	120.0	2.18	261.	<1.0
16	<0.02	0.12	350.0	1.0	960.0	30.0	68.0	130.0	2.36	234.	
17	<0.02	<0.02	680.	1.0	1660.0	35.0	84.0	125.0	2.30	235.	
18	<0.02	<0.02	220.	1.0	650.0	30.0	58.0	120.0	2.30	255.	
19	<0.02	<0.02	58.0	1.0	120.0	20.0	42.0	110.0	2.12	259.	
20	<0.02	<0.02	28.0	1.0	60.0	35.0	52.0	135.0	2.95	319.	<1.0
21	<0.02	<0.02	74.3	<1.0	30.0	35.0	58.0	135.0	4.60	1235.	
22	<0.02	<0.02	14.1	<1.0	20.0	15.0	39.0	90.0	2.48	269.	
23	<0.02	<0.02	14.8	<1.0	30.0	20.0	65.0	145.0	3.72	490.	
24	<0.02	<0.02	7.0	<1.0	30.0	25.0	37.0	90.0	3.19	540.	
25	<0.02	<0.02	11.8	<1.0	30.0	25.0	37.0	100.0	3.07	484.	<1.0
26	<0.02	<0.02	9.8	<1.0	20.0	10.0	31.0	135.0	2.71	448	
27	<0.02	<0.02	15.8	<1.0	40.0	30.0	37.0	90.0	2.54	511	
28	<0.02	<0.02	11.2	1.0	30.0	30.0	37.0	85.0	4.66	538	
29	<0.02	0.19	11.8	1.0	30.0	30.0	31.0	90.0	4.60	854	
30	<0.02	0.19	25.0	1.0	30.0	25.0	34.0	90.0	2.77	483	<1.0

* Based on dry weight of sample except where indicated.

APPENDIX 5: Net Set Results for Snow and Herblet Lakes;

Specifications	Snow Lake	Herblet Lake
Lift Date	81 07 10	81 07 08
Set Duration	24 hours	24 hours
Nets: Mesh 76.2 mm	91.4 m long x 1.83 m deep	91.4 m long x 1.83 m deep
95.3 mm	91.4 m long x 4.87 m deep	91.4 m long x 4.87 m deep
108 mm	91.4 m long x 3.66 m deep	91.4 m long x 3.66 m deep
Northern Pike	14	52
Common Sucker	18	155
Lake Whitefish	56	-
Cisco	7	22
Walleye	46	-

APPENDIX 6(a): General Meristics and Muscle Tissue Metal Concentrations; Snow Lake Northern Pike.

Length (cm)	Weight (g)	Sex	Age	Muscle Tissue Metal Levels (µg/g)						
				Hg (wet)	As	Cd	Cu	Pb	Ni	Zn
75.2	4150	F	9	0.36	<0.02	< 0.1	0.4	0.5	0.5	3.9
54.3	870	F	5	0.43	<0.02	< 0.1	0.3	0.5	1.0	5.4
67.3	2220	M	7	0.36	0.03	< 0.1	0.4	0.5	1.0	7.7
66.8	1770	F	5	0.25	<0.02	< 0.1	0.7	0.5	0.5	6.3
57.0	1710	F	5	0.29	0.06	< 0.1	0.6	1.0	1.0	7.0
58.4	1460	F	7	0.45	<0.02	< 0.1	0.5	< 0.5	0.5	5.4
56.3	1240	M	5	0.21	<0.02	0.1	0.6	1.0	<0.5	4.6
70.5	2460	F	8	0.27	<0.02	< 0.1	0.5	< 0.5	0.5	3.8
45.0	650	M	4	0.13	0.18	< 0.1	0.3	0.5	0.5	4.3
45.8	770	M	4	0.14	0.06	< 0.1	0.5	0.5	<0.5	7.5
62.8	1440	F	5	0.36	0.06	< 0.1	0.5	1.0	<0.5	4.8
55.3	1320	M	6	0.38	0.14	< 0.1	0.4	0.5	1.0	7.2
71.0	2940	F	8	0.40	0.26	< 0.1	0.2	0.5	<0.5	4.1
62.5	2270	F	7	0.26	<0.02	< 0.1	0.2	< 0.5	1.0	3.9

APPENDIX 6(b): General Meristics and Muscle Tissue Metal Concentrations; Snow Lake Common Sucker.

Length (cm)	Weight (g)	Sex	Age	Muscle Tissue Metal Levels (µg/g)						
				Hg (wet)	As	Cd	Cu	Pb	Ni	Zn
36.2	700	F	4	0.04	< 0.02	< 0.1	0.5	< 0.5	< 0.5	4.3
32.1	540	Imm	5	0.02	< 0.02	< 0.1	0.5	< 0.5	< 0.5	4.5
31.5	500	Imm	4	0.03	< 0.02	< 0.1	0.4	< 0.5	< 0.5	3.0
31.6	510	Imm	6	0.04	< 0.02	< 0.1	0.4	0.5	< 0.5	4.0
30.0	440	Imm	4	0.03	< 0.02	< 0.1	0.2	< 0.5	< 0.5	4.2
34.4	800	Imm	5	0.03	< 0.02	< 0.1	0.3	0.5	< 0.5	4.3
38.2	770	M	6	0.04	< 0.02	< 0.1	0.7	< 0.5	0.5	4.7
35.5	720	Imm	6	0.08	< 0.02	0.6	<0.1	< 0.5	0.5	4.5
30.2	430	Imm	4	0.03	0.07	< 0.1	0.5	< 0.5	0.5	4.2
33.2	620	M	5	0.08	0.03	< 0.1	0.5	< 0.5	< 0.5	3.8
34.9	650	Imm	5	0.09	0.03	< 0.1	0.6	< 0.5	0.5	3.9
33.6	600	Imm	6	0.03	0.04	< 0.1	0.5	< 0.5	0.5	3.4
27.5	310	Imm	2	<0.02	0.11	< 0.1	0.4	< 0.5	0.5	3.5
27.4	320	Imm	3	<0.02	0.06	< 0.1	0.5	< 0.5	0.5	4.5
29.6	390	Imm	5	0.02	0.04	< 0.1	0.5	< 0.5	0.5	4.5
28.0	360	Imm	3	0.02	0.07	< 0.1	0.3	< 0.5	< 0.5	3.9
38.2	360	Imm	4	0.03	0.27	< 0.1	0.4	< 0.5	< 0.5	3.4

APPENDIX 6(e): General Meristics and Muscle Tissue Metal Concentrations; Snow Lake Whitefish.

Length (cm)	Weight (g)	Sex	Age	Muscle Tissue Metal Levels (µg/g)						
				Hg (wet)	As	Cd	Cu	Pb	Ni	Zn
44.2	1030	F	29	0.05	0.08	< 0.1	0.3	< 0.5	< 0.5	4.9
38.0	830	F	10	0.12	0.06	< 0.1	0.2	< 0.5	< 0.5	3.6
42.1	1180	F	22	0.10	0.06	< 0.1	0.1	< 0.5	< 0.5	2.9
32.6	600	F	6	0.08	0.04	< 0.1	0.1	< 0.5	< 0.5	4.1
34.9	620	F	7	0.09	0.12	< 0.1	0.1	0.5	< 0.5	4.5
43.8	880	F	27	0.23	0.05	< 0.1	0.2	0.5	< 0.5	7.1
37.1	470	F	10	0.10	0.02	< 0.1	0.3	1.0	< 0.5	5.0
38.2	950	M	15	0.12	0.11	< 0.1	0.2	0.5	< 0.5	3.5
42.1	1220	F	26	0.23	0.33	< 0.1	0.2	1.0	< 0.5	3.8
40.3	970	F	26	0.25	0.10	< 0.1	0.3	< 0.5	< 0.5	4.3
34.4	710	M	6	0.10	0.11	< 0.1	0.2	< 0.5	< 0.5	3.3
35.1	710	M	6	0.05	0.13	< 0.1	0.3	< 0.5	< 0.5	5.2
35.2	740	M	8	0.06	0.07	< 0.1	0.3	< 0.5	< 0.5	4.3
40.1	1000	M	11	0.07	0.20	< 0.1	0.2	< 0.5	< 0.5	3.1
39.7	1180	F	10	0.12	0.08	< 0.1	0.2	< 0.5	< 0.5	4.7
36.4	860	M	13	0.04	0.08	< 0.1	0.2	< 0.5	< 0.5	4.5
39.8	950	F	10	0.10	0.08	< 0.1	0.5	< 0.5	< 0.5	4.1
37.2	820	F	10	0.08	0.12	< 0.1	0.1	< 0.5	< 0.5	2.9
38.0	820	F	11	0.12	0.09	< 0.1	0.5	0.5	< 0.5	3.7
39.3	910	F	14	0.20	0.20	< 0.1	0.1	< 0.5	< 0.5	2.9

APPENDIX 6(d): General Meristics and Muscle Tissue Metal Concentrations; Snow Lake Walleye.

Length (cm)	Weight (g)	Sex	Age	Muscle Tissue Metal Levels (µg/g)						
				Hg (wet)	As	Cd	Cu	Pb	Ni	Zn
40.0	710	F	6	0.15	0.08	< 0.1	0.1	< 0.5	0.5	4.0
43.4	940	F	6	0.19	0.30	< 0.1	0.2	< 0.5	< 0.5	3.7
33.3	460	F	5	0.14	0.10	< 0.1	0.7	< 0.5	1.0	3.7
41.1	840	F	6	0.20	0.07	< 0.1	0.7	0.5	1.0	4.1
39.5	750	M	6	0.17	0.09	< 0.1	0.5	< 0.5	< 0.5	4.1
50.5	1580	F	10	0.34	< 0.02	< 0.1	0.2	< 0.5	< 0.5	4.2
40.8	860	F	6	0.20	0.45	< 0.1	0.3	0.5	< 0.5	5.2
37.0	610	M	5	0.14	0.07	< 0.1	0.4	< 0.5	< 0.5	3.3
35.6	550	M	5	0.22	< 0.02	< 0.1	0.2	0.5	0.5	5.0
36.2	590	M	6	0.16	0.05	< 0.1	0.3	< 0.5	0.5	3.6
30.2	360	F	5	0.13	0.16	< 0.1	0.8	0.5	0.5	3.5
47.5	1200	F	9	0.26	0.08	< 0.1	0.7	< 0.5	< 0.5	3.7
37.1	640	M	6	0.23	< 0.02	< 0.1	0.4	< 0.5	0.5	3.0
38.9	710	F	6	0.16	< 0.02	< 0.1	0.2	< 0.5	< 0.5	3.9
49.6	1430	M	11	0.39	0.06	< 0.1	0.2	< 0.5	< 0.5	5.2
45.3	1100	F	17	0.48	< 0.02	< 0.1	0.3	< 0.5	0.5	4.0
33.8	520	M	5	0.13	0.05	< 0.1	1.1	< 0.5	< 0.5	3.8
34.5	590	F	6	0.19	0.04	< 0.1	0.3	< 0.5	< 0.5	6.3
35.5	540	F	6	0.18	< 0.02	< 0.1	0.3	< 0.5	0.5	4.5
29.8	350	M[illegible]	4	0.19	0.06	< 0.1	0.4	0.7	< 0.5	4.5

APPENDIX 7(a): General Meristics and Muscle Tissue Metal Concentrations; Herblet Lake Northern Pike.

Length (cm)	Weight (g)	Sex	Age	Muscle Tissue Metal Levels (µg/g)						
				Hg (wet)	As	Cd	Cu	Pb	Ni	Zn
45.2	700	M	5	0.32	0.05	< 0.1	0.2	< 0.5	< 0.5	5.4
42.8	590	M	5	0.27	0.20	< 0.1	0.1	< 0.5	< 0.5	5.3
42.8	620	M	4	0.24	0.15	< 0.1	0.1	< 0.5	< 0.5	3.8
46.2	650	F	4	0.34	0.97	< 0.1	<0.1	< 0.5	< 0.5	4.6
46.1	600	F	5	0.48	0.45	< 0.1	0.1	< 0.5	< 0.5	5.8
44.3	640	M	4	0.38	1.20	< 0.1	0.1	< 0.5	< 0.5	4.6
54.3	1000	M	6	0.54	0.43	< 0.1	0.2	< 0.5	< 0.5	4.4
43.9	640	M	5	0.19	0.30	< 0.1	0.2	< 0.5	0.6	4.9
47.5	640	F	5	0.36	2.20	< 0.1	0.2	< 0.5	0.6	5.9
54.7	1180	M	5	0.44	0.11	< 0.1	<0.1	< 0.5	< 0.5	5.6
52.4	700	F	5	0.65	0.34	< 0.1	0.2	< 0.5	0.6	8.2
47.3	760	M	4	0.38	0.28	< 0.1	0.3	< 0.5	0.6	4.3
50.0	920	F	4	0.20	0.68	< 0.1	0.2	< 0.5	< 0.5	4.2
52.4	1050	F	5	0.40	0.13	< 0.1	0.3	0.6	< 0.5	6.3
52.0	820	F	4	0.43	0.14	< 0.1	0.2	< 0.5	< 0.5	6.4
48.8	850	M	3	0.39	0.37	< 0.1	0.2	< 0.5	< 0.5	5.5
61.0	1500	F	5	0.36	0.14	< 0.1	0.2	< 0.5	< 0.5	4.4
53.4	1110	F	5	0.23	0.21	< 0.1	0.2	< 0.5	< 0.5	4.6
54.6	960	M	6	0.40	0.23	< 0.1	0.2	< 0.5	0.6	6.3
50.1	870	F	4	0.29	0.77	< 0.1	0.2	< 0.5	< 0.5	5.6

APPENDIX 7(b): General Meristics and Muscle Tissue Metal Concentrations; Herblet Lake Common Sucker.

Length (cm)	Weight (g)	Sex	Age	Muscle Tissue Metal Levels (µg/g)						
				Hg (wet)	As	Cd	Cu	Pb	Ni	Zn
37.0	760	F	6	0.07	0.08	<0.1	0.2	< 0.5	< 0.5	3.9
37.1	760	Imm	6	0.12	0.09	<0.1	0.2	< 0.5	0.5	5.2
38.1	820	F	5	0.12	0.17	<0.1	0.2	< 0.5	<0.5	4.5
38.6	920	F	5	0.08	0.09	<0.1	0.3	< 0.5	<0.5	4.3
35.8	720	M	4	0.05	0.14	<0.1	0.2	< 0.5	0.5	4.0
34.4	690	M	3	0.04	0.19	<0.1	0.2	0.5	0.5	5.2
38.2	800	M	6	0.10	0.17	<0.1	0.5	< 0.5	0.5	5.5
37.9	830	M	4	0.06	0.17	<0.1	0.2	< 0.5	0.5	3.9
34.6	610	M	5	0.06	0.14	<0.1	0.5	< 0.5	<0.5	5.2
32.2	580	Imm	5	0.03	0.35	<0.1	0.2	< 0.5	0.5	5.7
35.1	700	F	7	0.07	0.07	<0.1	0.3	< 0.5	0.5	5.2
37.5	920	F	5	0.03	0.11	<0.1	0.3	< 0.5	<0.5	3.8
33.9	540	Flmm	4	0.09	0.46	<0.1	0.7	< 0.5	<0.5	4.2
33.5	610	M	4	0.04	0.16	<0.1	0.2	< 0.5	0.5	4.3
44.3	1280	M	7	0.13	0.07	<0.1	0.4	< 0.5	0.5	5.2
38.2	880	F	5	0.08	0.10	0.1	0.3	< 0.5	0.5	3.8
36.0	680	M	5	0.09	0.13	<0.1	0.5	< 0.5	0.5	6.1
37.9	850	F	5	0.07	0.06	<0.1	0.4	< 0.5	<0.5	5.4
33.7	700	M	4	0.04	0.11	<0.1	0.3	< 0.5	0.8	3.3
36.8	920	F	5	0.06	0.19	<0.1	0.2	< 0.5	<0.5	3.4

APPENDIX 7(c): General Meristics and Muscle Tissue Metal Concentrations; Herblet Lake Cisco

Length (cm)	Weight (g)	Sex	Age	Muscle Tissue Metal Levels (µg/g)						
				Hg (wet)	As	Cd	Cu	Pb	Ni	Zn
27.7	400	M	4	0.09	0.23	< 0.1	0.2	< 0.5	0.5	5.7
31.2	540	F	5	0.16	0.24	< 0.1	0.2	< 0.5	< 0.5	6.7
29.2	500	M	5	0.07	0.29	< 0.1	0.2	< 0.5	0.5	5.2
30.6	540	F	6	0.10	0.46	< 0.1	0.2	< 0.5	0.5	9.8
30.0	560	M	6	0.13	0.25	< 0.1	0.2	< 0.5	0.5	6.9
25.8	300	Imm	3	0.07	0.33	< 0.1	0.2	< 0.5	< 0.5	4.8
29.2	460	F	5	0.09	0.37	< 0.1	0.2	< 0.5	< 0.5	5.2
30.6	590	F	7	0.18	0.34	< 0.1	0.3	< 0.5	0.5	14.5
30.0	480	F	4	0.11	0.55	< 0.1	0.2	< 0.5	0.5	14.0
33.5	620	M	11	0.33	0.37	< 0.1	0.1	< 0.5	0.5	7.1
24.9	260	Flmm	3	0.04	0.23	< 0.1	0.4	< 0.5	0.5	8.0
28.8	440	F	4	0.21	0.36	< 0.1	0.2	< 0.5	0.5	5.4
29.8	480	F	4	0.06	0.33	< 0.1	0.2	< 0.5	0.5	7.8
30.0	500	M	4	0.09	0.19	< 0.1	0.2	< 0.5	0.5	7.8
32.0	590	F	5	0.19	0.27	< 0.1	0.2	< 0.5	0.8	6.3
29.6	440	F	5	0.17	0.42	< 0.1	0.2	< 0.5	0.5	9.8
30.1	420	F	4	0.07	0.36	< 0.1	0.3	< 0.5	< 0.5	8.8
31.0	590	F	6	0.12	0.27	< 0.1	0.2	< 0.5	0.8	6.5
32.9	640	F	9	0.10	0.34	< 0.1	0.2	< 0.5	< 0.5	5.5
28.8	400	M	9	0.06	0.31	< 0.1	0.2	< 0.5	0.5	6.5

POOR

QUALITY

ORIGINAL